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NOT USED

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NOT USED

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SECTION 210513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Capacitor start, capacitor run.
- B. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 210513

SECTION 210517 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.
- C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.
- D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- E. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
 4. Metraflex Company (The).
 5. Proco Products, Inc.
- B. Description:
1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 2. Designed to form a hydrostatic seal of 20 psig minimum.
 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 4. Pressure Plates: Carbon steel or Composite plastic.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

2.3 GROUT

- A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

- 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 1-inch annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. 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.
2. Using grout, seal space outside of sleeves in slabs and walls without sleeve-seal system.
- 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 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 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, 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.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. 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.
- C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6 Cast-iron pipe sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves.
2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6 Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6 Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6 Steel pipe sleeves.
 - b. Piping NPS 6 and Larger: Steel pipe sleeves.
5. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. BrassCraft Manufacturing Co.; a Masco company.
2. Dearborn Brass.
3. Jones Stephens Corp.
4. Keeney Manufacturing Company (The).
5. Mid-America Fittings, Inc.
6. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

- A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
- D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

- A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- 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 piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping and Relocated Existing Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Chrome-Plated Piping: One-piece steel, cast brass or split-plate steel with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel **or** split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - 2. Escutcheons for Existing Piping to Remain:
 - a. Chrome-Plated Piping: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with polished, chrome-plated 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: Split floor plate.
 - 2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 210518

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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron butterfly valves with indicators.
2. Check valves.
3. Iron OS&Y gate valves.
4. NRS gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Fire Main Equipment:
 - a. Indicator Posts, Gate Valve.
 - b. Ball Valves, System Control.
 - c. Butterfly Valves.
 - d. Check Valves.
 - e. Gate Valves.
2. Sprinkler System & Water Spray System Devices:

- a. Valves, Trim and Drain.
 - B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
 - 1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves
 - 3) Miscellaneous valves.
 - C. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B31.9 for building services piping valves.
 - D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
 - E. NFPA Compliance for valves:
 - 1. Comply with NFPA 13, NFPA 14, NFPA 20, and NFPA 24.
 - F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher, as required by system pressures.
 - G. Valve Sizes: Same as upstream piping unless otherwise indicated.
 - H. Valve Actuator Types:
 - 1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 - 2. Handwheel: For other than quarter-turn trim and drain valves.
 - 3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.
- 2.3 IRON BUTTERFLY VALVES WITH INDICATORS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anvil International.
 - 2. Globe Fire Sprinkler Corporation.
 - 3. Kennedy Valve Company; a division of McWane, Inc.

4. NIBCO INC.
5. Tyco by Johnson Controls Company.
6. Victaulic Company.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer.

2.4 CHECK VALVES

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

1. Ames Fire & Waterworks; A WATTS Brand.
2. Anvil International.
3. FEBCO; A WATTS Brand.
4. Fire Protection Products, Inc.
5. Globe Fire Sprinkler Corporation.
6. Kennedy Valve Company; a division of McWane, Inc.
7. Mueller Co.
8. NIBCO INC.
9. Reliable Automatic Sprinkler Co., Inc. (The).
10. Tyco by Johnson Controls Company.
11. Victaulic Company.
12. Viking Corporation.
13. WATTS.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.

9. End Connections: Flanged, grooved, or threaded.

2.5 IRON OS&Y GATE VALVES

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

1. Clow Valve Company; a subsidiary of McWane, Inc.
2. Hammond Valve.
3. Kennedy Valve Company; a division of McWane, Inc.
4. Mueller Co.
5. NIBCO INC.
6. Victaulic Company.
7. WATTS.

- B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged.

2.6 NRS GATE VALVES

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

1. Clow Valve Company; a subsidiary of McWane, Inc.
2. Kennedy Valve Company; a division of McWane, Inc.
3. Mueller Co.
4. NIBCO INC.
5. Victaulic Company.

- B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.

4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged.

2.7 INDICATOR POSTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Clow Valve Company; a subsidiary of McWane, Inc.
 2. Kennedy Valve Company; a division of McWane, Inc.
 3. Mueller Co.
 4. NIBCO INC.
- B. Description:
1. Standard: UL 789 and FM Global standard for indicator posts.
 2. Type: Upright.
 3. Base Barrel Material: Cast or ductile iron.
 4. Extension Barrel: Cast or ductile iron.
 5. Cap: Cast or ductile iron.
 6. Operation: Wrench.

2.8 TRIM AND DRAIN VALVES

- A. Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Fire-End & Croker Corporation.
 - c. Flowserve Corporation.
 - d. FNW; Ferguson Enterprises, Inc.
 - e. Jomar Valve.
 - f. KITZ Corporation.
 - g. Legend Valve & Fitting, Inc.
 - h. Milwaukee Valve Company.
 - i. NIBCO INC.
 - j. Potter Roemer LLC; a Division of Morris Group International.
 - k. Red-White Valve Corp.
 - l. Tyco by Johnson Controls Company.

- m. Victaulic Company.
- n. WATTS.

2. Description:

- a. Pressure Rating: 175 psig.
- b. Body Design: Two piece.
- c. Body Material: Forged brass or bronze.
- d. Port size: Full or standard.
- e. Seats: PTFE.
- f. Stem: Bronze or stainless steel.
- g. Ball: Chrome-plated brass.
- h. Actuator: Handlever.
- i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
- j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2 : Grooved ends.

B. Angle Valves:

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

- a. Fire Protection Products, Inc.
- b. NIBCO INC.
- c. United Brass Works, Inc.

2. Description:

- a. Pressure Rating: 175 psig.
- b. Body Material: Brass or bronze.
- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc: Bronze.
- f. Packing: Asbestos free.
- g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

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

- a. NIBCO INC.
- b. United Brass Works, Inc.

2. Description:

- a. Pressure Rating: 175 psig.
- b. Body Material: Bronze with integral seat and screw-in bonnet.

- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc Holder and Nut: Bronze.
- f. Disc Seat: Nitrile.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with requirements in the following Sections for specific valve-installation requirements and applications:
 - 1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for application of valves in fire-suppression water-service piping.
 - 2. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
 - 3. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply, except from fire-department connections. Install permanent identification signs, indicating portion of system controlled by each valve.
- C. Install double-check valve assembly in each fire-protection water-supply connection.
- D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the pipe center.
- F. Install valves in position to allow full stem movement.
- G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 210523

SECTION 210529 - HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fastener systems.
4. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 210516 "Expansion Fittings and Loops for Fire-Suppression Piping" for pipe guides and anchors.
3. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices and seismic restraints.

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

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

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

- B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 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 pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
- C. NFPA Compliance: Comply with NFPA 13.
- D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 TRAPEZE PIPE HANGERS

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

2.4 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC.
 - d. Simpson Strong-Tie Co., Inc.
 - 2. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate fManufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - d. MKT Fastening, LLC.
- B. or supported loads and building materials where used.
 - 1. Indoor Applications: Zinc-coated or Stainless steel.
 - 2. Outdoor Applications: Stainless steel.

2.5 EQUIPMENT SUPPORTS

- A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.6 MATERIALS

- A. Aluminum: ASTM B221
- 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 shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. 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 from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.
 - 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

- D. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- E. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- F. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- G. Install lateral bracing with pipe hangers and supports to prevent swaying.
- H. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- I. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- J. 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.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 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 because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 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.

3.6 PAINTING

- A. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099113 "Exterior Painting."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with NFPA requirements 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 carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
 - 3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
- H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- I. Hanger-Rod Attachments: Comply with NFPA requirements.
- J. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. C-Clamps (MSS Type 23): For structural shapes.
 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- K. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- L. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING
AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Restraints - rigid type.
5. Restraints - cable type.
6. Restraint accessories.
7. Post-installed concrete anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated-Design Submittal:

1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
 - a. Seismic- and Wind-Load-Restraint Selection: Select seismic and wind-load restraints complying with performance requirements, design criteria, and analysis data.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.

- c. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
 - d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
 - e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" in "Performance Requirements" Article.
 - f. Qualified Professional Engineer: All designated-design submittals for seismic and wind-load-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
 - 2. Seismic- and Wind-Load-Restraint Detail Drawing:
 - 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-load restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
 - 3. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
 - 4. All delegated-design submittals for seismic- and wind-load-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
- D. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
- 1.3 INFORMATIONAL SUBMITTALS
- A. Coordination Drawings: Show coordination of seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
 - B. Welding certificates.
 - C. Field quality-control reports.

- D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-10, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
1. Provide equipment manufacturer's written certification for each designated active fire-suppression system seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction.
 2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-10.
 3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
 4. The following fire-suppression system systems and components are Designated Seismic Systems and require written special certification of seismic qualification by manufacturer:
 - a. Fire pumps.
- E. Wind-Load Performance Certification: Provide special certification for fire-suppression system components subject to high-wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-load performance certification.
1. Provide equipment manufacturer's written certification for each designated fire-suppression system device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
 2. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to 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: ICC-ES product listing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind-load control system.
1. Seismic Performance: Equipment must be designed and secured to withstand the effects of earthquake motions determined in accordance with NFPA 13 and ASCE/SEI 7-10.
 2. Wind-Load Performance: Equipment must be designed and secured to withstand the effects of high wind events determined in accordance with ASCE/SEI 7-10.
- B. Seismic Design Calculations:
1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in NFPA 13 and ASCE/SEI 7-10 including supplement No. 1. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text.
 - a. Data indicated below to be determined by Delegated-Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
 - c. Building Occupancy Category: IV.
 - d. Building Risk Category: IV.
 - e. Building Site Classification D.
 2. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise noted.
 - a. Horizontal Seismic Design Force F_p : Value is to be calculated by Delegated-Design Contractor using Equation 13.3-1. Factors below must be obtained for this calculation.
 - 1) S_{DS} = Spectral Acceleration: 0.674. Value applies to all components on Project.
 - 2) a_p = Component Amplification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 3) I_p = Component Importance Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from each component submittal.
 - 5) R_p = Component Response Modification Factor: To be obtained by the Delegated-Design Contractor for each component.

- 6) z = Height in Structure of Point of Attachment of Component for Base: Determine from Project Drawings for each component by Delegated-Design Contractor. For items at or below the base, " z " shall be taken as zero.
- 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
- b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.
- c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.2. Factors below must be obtained for this calculation:
 - 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated-Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 4) δ_{yA} = Deflection at Building Level y of Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 5) δ_{yB} = Deflection at Building Level y of Structure B: To be obtained by the Delegated-Design Contractor for each component.
 - 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 8) Δ_{aA} = Allowable Story Drift for Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 9) Δ_{aB} = Allowable Story Drift for Structure B: To be obtained by the Delegated-Design Contractor for each component.
 - 10) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a : To be obtained by the Delegated-Design Contractor for each component.
- d. Component Fundamental Period T_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:
 - 1) W_p = Component Operating Weight: Determined by contractor from Project Drawings and manufacturer's data.
 - 2) g = Gravitational Acceleration: 32.17 fps^2 .
 - 3) K_p = Combined Stiffness of Component, Supports, and Attachments: Determined by delegated-design seismic engineer.

3. Calculation Factors, ASCE/SEI 7-10, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-10 unless otherwise noted.
 - a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-10, Equation 13.3-1. Factors below must be obtained for this calculation.
 - 1) S_{DS} = Spectral Acceleration: To be obtained by the Delegated-Design Contractor. Value applies to all components on Project.
 - 2) a_p = Component Amplification Factor: To be obtained by the Delegated-Design Contractor.
 - 3) I_p = Component Importance Factor: To be obtained by the Delegated-Design Contractor.
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from equipment submittal.
 - 5) R_p = Component Response Modification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determined from Project Drawings for each component by Contractor. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
 - b. Vertical Seismic Design Force: Calculate by Delegated-Design Contractor using method explained in ASCE/SEI 7-10, Paragraph 13.3.1.
 - c. Seismic Relative Displacement D_p : Calculate by Delegated-Design Contractor using methods explained in ASCE/SEI 7-10, Paragraph 13.3.2. Factors below must be obtained for this calculation:
 - 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculate by Delegated-Design Contractor in accordance with ASCE/SEI 7-10, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A To be obtained by the Delegated-Design Contractor for each component.
 - 4) δ_{yA} = Deflection at Building Level y of Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 5) δ_{yB} = Deflection at Building Level y of Structure B: To be obtained by the Delegated-Design Contractor for each component.
 - 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.

- 8) Δ_{aA} = Allowable Story Drift for Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 9) Δ_{aB} = Allowable Story Drift for Structure B: To be obtained by the Delegated-Design Contractor for each component.
 - 10) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a : To be obtained by the Delegated-Design Contractor for each component.
4. Calculation Factors, ASCE/SEI 7-05, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-05 unless otherwise noted.
- a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-05, Equation 13.3-1. Factors below must be obtained for this calculation:
 - 1) S_{DS} = Spectral Acceleration: 0.674. Value applies to all components on Project.
 - 2) a_p = Component Amplification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 3) I_p = Component Importance Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 4) W_p = Component Operating Weight: Obtain by Delegated-Design Contractor for each component from component submittal.
 - 5) R_p = Component Response Modification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determine by Delegated-Design Contractor for each component from Project Drawings. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine by Delegated-Design Contractor from Project Drawings.
 - b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-05, Paragraph 13.3.1.
 - c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-05, Paragraph 13.3.2. Factors below must be obtained for this calculation:
 - 1) δ_{xA} = Deflection at Building Level x of Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 2) δ_{yA} = Deflection at Building Level y of Structure A: To be obtained by the Delegated-Design Contractor for each component.
 - 3) δ_{yB} = Deflection at Building Level y of Structure B: To be obtained by the Delegated-Design Contractor for each component.
 - 4) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.

- 5) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
- 6) Δ_{aA} = Allowable Story Drift for Structure A: To be obtained by the Delegated-Design Contractor for each component.
- 7) Δ_{aB} = Allowable Story Drift for Structure B: To be obtained by the Delegated-Design Contractor for each component.
- 8) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a : To be obtained by the Delegated-Design Contractor for each component.

C. Wind-Load Design Calculations:

1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-10. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise noted.
 - a. Factors indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
2. Design wind pressure "p" for external sidewall-mounted equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-10, Ch. 30. Perform calculations in accordance with the following, as appropriate:
 - a. PART 1: Low-Rise Buildings.
 - b. PART 2: Low-Rise Buildings (Simplified).
 - c. PART 3: Buildings with "h" greater than 60 feet.
 - d. PART 4: Buildings with "h" less than 160 feet.
 - e. PART 5: Open Buildings.

D. Consequential Damage: Provide additional seismic and wind-load restraints for suspended fire-suppression system components or anchorage of floor-, roof-, or wall-mounted fire-suppression system components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential fire-suppression system component will not cause the failure of any other essential architectural, mechanical, or electrical building component.

E. Fire/Smoke Resistance: Seismic- and wind-load-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 an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

F. Component Supports:

1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Isolation Technology, Inc.
 - b. Kinetics Noise Control, Inc.
 - c. Korfund.
 - d. Mason Industries, Inc.
 - e. Vibration Eliminator Co., Inc.
 - f. Vibration Isolation.
 - g. Vibration Management Corp.
 - h. Vibration Mountings & Controls, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.
6. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Isolation Technology, Inc.
 - b. Kinetics Noise Control, Inc.
 - c. Korfund.
 - d. Mason Industries, Inc.
 - e. Vibration Eliminator Co., Inc.
 - f. Vibration Isolation.
 - g. Vibration Management Corp.
 - h. Vibration Mountings & Controls, Inc.

2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Isolation Technology, Inc.
 - b. Kinetics Noise Control, Inc.
 - c. Korfund.
 - d. Mason Industries, Inc.
 - e. Vibration Eliminator Co., Inc.
 - f. Vibration Isolation.
 - g. Vibration Management Corp.
 - h. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with seismic 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.

2.5 RESTRAINTS - RIGID TYPE

- ### A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line; Eaton, Electrical Sector.
 2. Hilti, Inc.
 3. Isolation Technology, Inc.
 4. TOLCO.
 5. Unistrut; Atkore International.
 6. Vibration Mountings & Controls, Inc.

- B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, 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.

2.6 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line; Eaton, Electrical Sector.
 - 2. Hilti, Inc.
 - 3. Mason Industries, Inc.
 - 4. TOLCO.
 - 5. Unistrut; Atkore International.
- B. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Non-metallic stiffeners are unacceptable.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid restraints.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.7 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.

- f. Unistrut; Atkore International.
- 2. 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. Provide post-installed concrete anchors that have been prequalified for use in seismic applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-10, Ch. 13.
 - 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry calculated static, wind load, and seismic loads within specified loading limits.

3.2 INSTALLATION OF VIBRATION CONTROL, WIND-LOAD-RESTRAINT, AND SEISMIC-RESTRAINT DEVICES

- A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Fire-Suppression Vibration Isolation, Seismic, and Wind-Load-Restraint Schedule, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.
- B. Provide seismic-restraint and wind-load-restraint devices for systems and equipment where indicated in Equipment Schedules or Vibration Isolation, Seismic, and Wind-Load-Restraint Schedules, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

- C. 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."
- D. Installation of vibration isolators, wind-load restraints, and seismic restraints must not cause any stresses, misalignment, or change of position of equipment or piping.
- E. Comply with installation requirements of NFPA 13 for installation of all seismic-restraint devices.
- F. Comply with requirements in Section 077200 "Roof Accessories" for installation of equipment supports and roof penetrations.
- G. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- H. Piping Restraints:
 - 1. Comply with all requirements in NFPA 13.
 - 2. Design piping sway bracing in accordance with NFPA 13.
 - a. Maximum spacing of all sway bracing to be no greater than indicated in NFPA 13.
 - b. Design loading of all sway bracing not to exceed values indicated in NFPA 13.
- I. Install seismic- and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- K. 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.
- L. 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.
- M. 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 the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross structural seismic joints and other points where differential movement may occur, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," and Section 211313 "Wet-Pipe Sprinkler Systems," for piping flexible connections.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. 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 at 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.
 6. Measure isolator restraint clearance.

- 7. Measure isolator deflection.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 210548

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- 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 and the proposed content for each label.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Craftmark Pipe Markers.
 - d. emedco.
 - e. Marking Services, Inc.
 - f. Seton Identification Products; a Brady Corporation company.
2. Material and Thickness: Stainless steel, 0.025 inch or anodized aluminum, 0.032 inch thick, with predrilled or stamped holes for attachment hardware.
3. Letter and Background Color: As indicated for specific application under Part 3.

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.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Craftmark Pipe Markers.
 4. emedco.
 5. Marking Services Inc.
 6. National Marker Company.
 7. Seton Identification Products; a Brady Corporation company.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances 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.
- G. Fasteners: Stainless steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.
- J. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Craftmark Pipe Markers.
 - 4. emedco.
 - 5. Marking Services Inc.
 - 6. Seton Identification Products; a Brady Corporation company.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include the following:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances].

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 installed.
- 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 fire-suppression equipment.
- B. Sign and Label Colors:
 - 1. White letters on an ANSI Z535.1 safety-red 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 arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 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. 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 a 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.
- D. Flow- Direction Arrows: Provide arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Fire-Suppression Pipe Label Color Schedule:
1. Fire-Suppression Pipe Labels: White letters on an ANSI Z535.1 safety-red background.

END OF SECTION 210553

SECTION 210800 - COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following fire-suppression systems, assemblies, and equipment:
 - 1. Water-based fire-suppression systems.
 - 2. Fire-extinguishing systems.
 - 3. Fire pumps.
 - 4. Fire-suppression water storage.
- 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 21 Sections specifying fire-suppression 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. "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. 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 NFPA 3 and to resolve any issues with the CxA.
- B. 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. 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS:

A. Perform Cx process for fire-suppression system in accordance with the following:

1. Section 019113 "General Commissioning Requirements."
2. NFPA 3.
3. Cx standards acceptable to the authority having jurisdiction.

3.2 CONSTRUCTION CHECKLISTS

- ##### A.
- Preliminary detailed construction checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each fire-suppression system, assembly, subsystem,

equipment, and component required to be commissioned, as detailed in NFPA 3. Contractor performs the following:

1. Review fire-suppression system 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)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed, and provide pertinent details and other information.

B. Additional systems required to be commissioned:

1. Facility fire-suppression water-distribution piping outside the building, including the following:
 - a. Fire-suppression water piping, fittings, and specialties outside the building.
 - b. Hydrants and fire-department connections.
 - c. Fire-alarm devices.
 - d. Meters and meter pits.
 - e. Outdoor water-storage tanks.
 - f. Sleeves and sleeve seals.
 - g. Meters and gauges.
 - h. General-duty and specialty valves.
 - i. Hangers and supports.
 - j. Vibration isolation and seismic restraints.
 - k. Identification.
 - l. Insulation.
2. Fire-suppression standpipes, including the following:
 - a. Fire-suppression water piping, fittings, and specialties inside the building.
 - b. Fire-department connections.
 - c. Fire pumps, motors, accessories, and controls.
 - d. Pressure-maintenance pumps, motors, accessories, and controls.
 - e. Sleeves and sleeve seals.
 - f. Indoor water-storage tanks.
 - g. Meters and gauges.
 - h. General-duty and specialty valves.
 - i. Hangers and supports.
 - j. Heat tracing.
 - k. Vibration isolation and seismic restraints.
 - l. Identification.
 - m. Insulation.

3. Fire-suppression sprinkler systems, including the following:
 - a. Wet-pipe sprinkler piping, fittings, sprinklers, and specialties.
 - b. Fire pumps, motors, accessories, and controls.
 - c. Pressure-maintenance pumps, motors, accessories, and controls.
 - d. Sleeves and sleeve seals.
 - e. Meters and gauges.
 - f. General-duty and specialty valves.
 - g. Hangers and supports.
 - h. Heat tracing.
 - i. Vibration isolation and seismic restraints.
 - j. Identification.
 - k. Insulation.
4. Documentation
 - a. Fire-suppression system operating manuals.
 - b. Documentation of required Cx.
 - c. Documentation of required operator training.

3.3 Cx TESTING PREPARATION

- A. Certify that fire-suppression 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 fire-suppression system instrumentation and control systems have been completed and calibrated, that they are operating in accordance with the Contract Documents and approved submittals, and that pretest set points have been recorded.
- 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 fire-suppression 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 FIRE-SUPPRESSION 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 21 Sections specifying fire-suppression 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.

3.6 CONSTRUCTION CHECKLIST EXAMPLES

- A. Vibration Isolation in Fire-Suppression Systems:
 1. Prerequisites: Acceptance of results of construction checklists for vibration and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment".
 2. Components to Be Tested:
 - a. Vibration isolation control devices in water-based fire-suppression systems.
 - b. Seismic control devices for proper device selection and installation.
 - c. Support systems.

3. Test Purpose: Evaluate effectiveness of vibration isolation and proper installation of seismic control devices.
 4. Test Conditions: Measure vibration of the facility structure at [three] <Insert number> locations designated by Owner's witness while the isolated equipment operates.
 5. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.
- B. Supervision of Fire-Protection Valves in Water-Based Fire-Suppression Systems:
1. Prerequisites: Acceptance of results of construction checklists for valves specified in the following Sections:
 - a. Section 210523 "General-Duty Valves for Water-Based Fire Protection Piping."
 - b. Section 211100 "Facility Fire-Suppression Water-Service Piping."
 - c. Section 211200 "Fire-Suppression Standpipes."
 - d. Section 211313 "Wet-Pipe Sprinkler Systems."
 - e. Section 284621.11 "Addressable Fire-Alarm Systems."
 - f. Section 284621.13 "Conventional Fire-Alarm Systems."
 2. Equipment and Systems to Be Tested:
 - a. Supervised valves in water-based fire-suppression systems.
 - b. Division 28 fire-detection and -alarm systems.
 3. Test Purpose: Verify generation of supervisory alarm at the fire-alarm control panel in response to activation of valve supervision device or tamper switch.
 4. Test Conditions:
 - a. Fire-alarm system operating in normal, automatic mode.
 - b. Activate valve supervision devices and tamper switches, one at a time.
 5. Acceptance Criteria: Activation of valve supervision device or tamper switch generates supervisory alarm at fire-alarm control panel.

END OF SECTION 210800

SECTION 211100 - FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes fire-suppression water-service piping and related components outside the building and service entrance piping through wall or floor into the building and the following:
 - 1. Pipes, fittings, and specialties.
 - 2. Fire-suppression specialty valves.
 - 3. Concrete vaults.
 - 4. Protective enclosures.
 - 5. Alarm devices.
- B. Related Requirements:
 - 1. Section 211116 "Facility Fire Hydrants" for AWWA and UL-listed, dry- and wet-barrel fire hydrants.
 - 2. Section 211119 "Fire-Department Connections" for exposed-, flush-, and yard-type, fire-department connections.
 - 3. Section 211200 "Fire-Suppression Standpipes" for fire-suppression standpipes inside the building.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying the water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

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 FM Global's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

A. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.

B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.

C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end.

D. Grooved-End, Ductile-Iron Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Shurjoint-Apollo Piping Products USA Inc.
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.
 - e. Viking Corporation.
2. Grooved-End, Ductile-Iron Fittings: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe.

3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- E. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- F. Push-on-Joint, Ductile-Iron Fittings: AWWA C153, ductile-iron compact pattern.
 1. Gaskets: AWWA C111, rubber.
- G. Flanges: ASME B16.1, Class 125, cast iron.

2.2 SPECIAL PIPE FITTINGS

A. Ductile-Iron Flexible Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. EBAA Iron, Inc.
 - b. Romac Industries, Inc.
 - c. Zurn Industries, LLC.
2. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
3. Pressure Rating: 250 psig minimum.

B. Ductile-Iron Deflection Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. EBAA Iron, Inc.
2. Description: Compound, ductile-iron coupling fitting with sleeve and one or two flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
3. Pressure Rating: 250 psig minimum.

2.3 JOINING MATERIALS

- A. Gaskets for Ferrous Piping and Copper-Alloy Tubing: ASME B16.21, asbestos free.
- B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series.

2.4 CURB VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A.Y. McDonald Mfg. Co.
 - 2. Ford Meter Box Company, Inc. (The).
 - 3. Master Meter, Inc.
 - 4. Mueller Co.
 - 5. Red Hed Manufacturing Company; a division of Everett J. Prescott, Inc.
- B. Curb Valves: Comply with AWWA C800 for high-pressure, service-line valves. Valve has bronze body, ground-key plug or ball, wide tee head, and inlet and outlet matching service piping material.
- C. 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," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches in diameter.
 - 1. Shutoff Rods: Steel; with tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.5 BACKFLOW PREVENTERS

- A. Double-Check, Detector-Assembly Backflow Preventers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. FEBCO; A WATTS Brand.
 - c. Mueller Co.
 - d. WATTS.
 - e. Zurn Industries, LLC.
 - 2. Standards: ASSE 1048 and UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
 - 3. Operation: Continuous-pressure applications.

4. Pressure Loss: 5 psig maximum, through middle one-third of flow range.
5. Body Material: Cast iron with interior lining complying with AWWA C550 or that is FDA approved or Stainless steel.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
 - a. Valves: UL 262 and FM Global's "Approval Guide" listing; OS&Y gate type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

B. Backflow Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; A WATTS Brand.
 - b. FEBCO; A WATTS Brand.
 - c. Flomatic Valves.
 - d. WATTS.
 - e. Zurn Industries, LLC.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.6 CONCRETE VAULTS

- A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C857, and made according to ASTM C858.
- B. Ladder: ASTM A36/A36M, steel ladder; or PE-encased steel steps.
- C. Manhole: ASTM A48/A48M, Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
 1. Dimension: 24-inch minimum diameter unless otherwise indicated.
- D. Manhole: ASTM A536, Grade 60-40-18, ductile-iron traffic frame and cover.
 1. Dimension: 24-inch minimum diameter unless otherwise indicated.
- E. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.7 ALARM DEVICES

- A. General: UL 753 and FM Global's "Approval Guide" listing, of types and sizes to mate and match piping and equipment.
- B. Water-Flow Indicators: Vane-type water-flow detector, rated for 250-psig working pressure; designed for horizontal or vertical installation; with two single-pole, double-throw circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.
- C. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.
- D. Pressure Switches: Single pole, double throw; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

- A. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- B. Make connections larger than NPS 2 with tapping machine according to the following:
 - 1. Install tapping sleeve and tapping valve according to MSS SP-60.
 - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
 - 4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- C. Comply with NFPA 24 for fire-service-main piping materials and installation.
- D. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
- E. Bury piping with depth of cover over top at least 12 inches, with top at least 12 inches below level of maximum frost penetration, and according to the following:

1. Under Driveways: With at least 36 inches of cover over top.
 2. In Loose Gravelly Soil and Rock: With at least 12 inches of additional cover.
- F. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- G. Extend fire-suppression water-service piping and connect to water-supply source and building fire-suppression water-service piping systems at locations and pipe sizes indicated.
1. Terminate fire-suppression water-service piping within the building at the **floor slab** or **wall** until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building's fire-suppression water-service piping systems when those systems are installed.
- H. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
- I. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," and Section 211313 "Wet-Pipe Sprinkler Systems," for fire-suppression-water piping inside the building.
- J. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- K. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure rating same as or higher than systems pressure rating for aboveground applications unless otherwise indicated.
- B. Install flanges, flange adaptors, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- C. Ream ends of tubes and remove burrs.
- D. Remove scale, slag, dirt, and debris from outside and inside of pipes, tubes, and fittings before assembly.
- E. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
- F. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts.

- G. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with bolts according to ASME B31.9.
- H. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.
- I. Do not use flanges or unions for underground piping.

3.4 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
 - 1. Concrete thrust blocks.
 - 2. Locking mechanical joints.
 - 3. Bolted flanged joints.
 - 4. Pipe clamps and tie rods.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches in fire-suppression water-service piping according to NFPA 24 and the following:
 - 1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. UL-Listed or FM Global-Approved Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
- D. UL-Listed or FM Global-Approved Valves Other Than Gate Valves: Comply with NFPA 24.
- E. MSS Valves: Install as component of connected piping system.
- F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

- G. Support valves and piping, not direct buried, on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

3.6 DETECTOR CHECK VALVE INSTALLATION

- A. Install in vault or aboveground.
- B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.
- C. Support detector check valves and piping on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

3.7 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
- C. Do not install bypass piping around backflow preventers.
- D. Support NPS 2-1/2 and larger backflow preventers and piping on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

3.8 CONCRETE VAULT INSTALLATION

- A. Install precast concrete vaults according to ASTM C891.

3.9 FIRE-DEPARTMENT CONNECTION INSTALLATION

- A. Install ball drip valves at each check valve for fire-department connection to mains.
- B. Install protective pipe bollards on three sides of each freestanding fire-department connection. Pipe bollards are specified in Section 055000 "Metal Fabrications."

3.10 ALARM DEVICE INSTALLATION

- A. Supervisory Switches: Supervise valves in open position.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
 2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.
- B. Locking and Sealing: Secure unsupervised valves as follows:
1. Valves: Install chain and padlock on open OS&Y gate valve.
 2. Post Indicators: Install padlock on wrench on indicator post.
- C. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.
- D. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.
- E. Connect alarm devices to building's fire-alarm system. Wiring and fire-alarm devices are specified in Section 284621.13 "Conventional Fire-Alarm Systems."

3.11 CONNECTIONS

- A. Connect fire-suppression water-service piping to utility water main. Use tapping sleeve and tapping valve.
- B. Connect fire-suppression water-service piping to interior fire-suppression piping.
- C. Connect waste piping from concrete vault drains to sanitary sewerage system. Comply with requirements in Section 334100 "Storm Utility Drainage Piping" for connection to storm sewer.

3.12 FIELD QUALITY CONTROL

- A. Use test procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described below.
- B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- C. Hydrostatic Tests: Test at not less than one-and-one-half times the working pressure for two hours.
 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for one hour; decrease to zero psig. Slowly increase again to test pressure and hold for one more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

- D. Prepare test and inspection reports.

3.13 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground fire-suppression water-service piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

3.14 PIPING SCHEDULE

- A. Underground fire-suppression water-service piping NPS 4 to NPS 12 shall be one of the following:
 - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
 - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
 - 3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
- B. Aboveground and vault fire-suppression water-service piping NPS 4 to NPS 12 shall be grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
- C. Underslab fire-suppression water-service piping NPS 4 to NPS 12 shall be one of the following:
 - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
 - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and restrained, gasketed joints.
 - 3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and restrained, gasketed joints.

3.15 VALVE SCHEDULE

- A. Underground fire-suppression water-service shutoff valves NPS 3 and larger shall be the following:
 - 1. 175-psig, UL-listed or FM Global-approved, iron, nonrising-stem gate valves.
- B. Indicator-post underground fire-suppression water-service valves NPS 3 and larger shall be

1. 175-psig, UL-listed FM Global-approved, iron, nonrising-stem gate valves with indicator-post flange.
- C. Standard-pressure, aboveground and vault fire-suppression water-service shutoff valves NPS 3 and larger shall be one of the following:
1. 175-psig, UL-listed or FM Global-approved, iron, OS&Y gate valves.
 2. AWWA or UL-listed or FM Global-approved butterfly valves.
- D. Fire-suppression water-service check valves NPS 3 and larger shall be one of the following:
1. AWWA or UL-listed or FM Global-approved check valves.
 2. UL-listed or FM Global-approved detector check valves.

END OF SECTION 211100

SECTION 211116 - FACILITY FIRE HYDRANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wet-barrel fire hydrants.

B. Related Requirements:

1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for piping and specialties for facility fire-suppression water-service piping outside the building and for service entrance piping into the building at the floor slab or wall.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For fire hydrants to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 WET-BARREL FIRE HYDRANTS

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

1. American AVK Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Jones, James Company.
4. Mueller Co.

- B. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets; and with NPS 6 threaded or flanged inlet, and base section with NPS 6 mechanical-joint inlet.

- C. Standards: UL 246 and FM Global's "Approval Guide."

- D. Design: Wet barrel.
- E. Pressure Rating: 175 psig minimum.
- F. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
- G. Operating and Cap Nuts: Pentagon, 1-1/2 inches point to flat.
- H. Direction of Opening: Hydrant valves open by turning operating nut to left or counterclockwise.
- I. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.

PART 3 - EXECUTION

3.1 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.
- B. Wet-Barrel Fire Hydrants: Install with valve below the frost line. Provide for drainage.
- C. Comply with NFPA 24.

END OF SECTION 211116

SECTION 211119 – FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exposed-type fire-department connections.
2. Flush-type fire-department connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

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

1. Elkhart Brass Mfg. Co., Inc.
2. Fire Protection Products, Inc.
3. Fire-End & Croker Corporation.
4. Guardian Fire Equipment, Inc.

B. Standard: UL 405.

C. Type: Exposed, projecting, for wall mounting.

D. Pressure Rating: 175 psig minimum.

E. Body Material: Corrosion-resistant metal.

F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Round, brass, wall type.
- I. Outlet: Back, with pipe threads.
- J. Number of Inlets: Two.
- K. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
- L. Finish: Rough brass or bronze.
- M. Outlet Size: NPS 6.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install wall-type fire-department connections.
- B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 211119

SECTION 211200 - FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection specialty valves.
3. Hose connections.
4. Alarm devices.
5. Pressure gauges.

B. Related Requirements:

1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
2. Section 211119 "Fire Department Connections" for exposed-, fire-department connections.
3. Section 211100 "Facility Fire-Suppression Water-Service Piping" for water-service piping; ductile-iron expansion joints and deflection fittings; backflow preventers; and protective enclosures.
4. Section 211213 "Fire-Suppression Hoses and Nozzles" for rack-type hose stations.
5. Section 211313 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.
6. Section 284621.11 "Addressable Fire-Alarm Systems" for connections to alarm devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire-suppression standpipes.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For standpipe 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.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, drawn to scale, or BIM model, showing the items described in this Section and coordinated with all building trades.
- B. Approved Standpipe Drawings: Working plans, prepared in accordance with NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- C. Welding certificates.
- D. Fire-hydrant flow test report.
- E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
- F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

- A. Automatic Wet-Type, Class I and Class III Standpipe Systems: Includes NPS 2-1/2 hose connections, has open water-supply valve with pressure maintained, and is capable of supplying water demand.

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. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14.
- C. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.
- D. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- E. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
 - 1. Minimum residual pressure at each hose-connection outlet is as follows:
 - a. NPS 1-1/2 Hose Connections: 65 psig.
 - b. NPS 2-1/2 Hose Connections: 100 psig.
- F. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined in accordance with NFPA 13 and ASCE/SEI 7. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

2.3 PIPING MATERIALS

- A. Comply with requirements in Part 3 "Piping Schedule" Article for applications of pipe, tube, and fitting materials and for joining methods for specific services, service locations, and pipe sizes.

2.4 BLACK STEEL PIPE AND ASSOCIATED FITTINGS

- A. Schedule 40: ASTM A53/A53M, Type E, Grade B, with factory- or field-formed ends to accommodate joining method.

- B. Schedule 30: ASTM A53/A53M, Type E, Grade B, with factory- or field-formed ends to accommodate joining method.
- C. Uncoated, Steel Couplings: ASTM A865/A865M, threaded.
- D. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- E. Malleable- or Ductile-Iron Unions: UL 860.
- F. Cast-Iron Flanges: ASME B16.1, Class 125.
- G. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
- H. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
- I. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Shurjoint-Apollo Piping Products USA Inc.
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.
 - 2. Pressure Rating: 175-psig minimum.
 - 3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A47/A47M malleable-iron casting or ASTM A536 ductile-iron casting, with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.5 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
 - 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1 carbon steel unless otherwise indicated.
- C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating:
 - a. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.
 - e. Viking Corporation.
2. Standard: UL 193.
3. Design: For horizontal or vertical installation.
4. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco by Johnson Controls Company.
2. Standard: UL 1726.
3. Pressure Rating: 175-psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.7 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Potter Roemer LLC; a Division of Morris Group International.
 - c. Tyco by Johnson Controls Company.
2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300-psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 1-1/2 or NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads in accordance with NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle or gate.
9. Finish: Rough brass or bronze.

2.8 ALARM DEVICES

- A. Match alarm-device material and connection types to piping and equipment materials and connection types.
- B. Water-Flow Indicators:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McDonnell & Miller.
 - b. Potter Electric Signal Company, LLC.
 - c. System Sensor.
 - d. Viking Corporation.
 2. Standard: UL 346.
 3. Water-Flow Detector: Electrically supervised.
 4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
 5. Type: Paddle operated.
 6. Pressure Rating: 250 psig.
 7. Design Installation: Horizontal or vertical.
- C. Pressure Switches:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Potter Electric Signal Company, LLC.
 - b. System Sensor.
 - c. Tyco by Johnson Controls Company.
 - d. United Electric Controls Co.
 - e. United Technologies Corporation (UTC Climate, Controls & Security - Kidde).
 - f. Viking Corporation.
2. Standard: UL 346.
 3. Type: Electrically supervised water-flow switch with retard feature.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design Operation: Rising pressure signals water flow.

D. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms; Honeywell International, Inc.
 - b. Kennedy Valve Company; a division of McWane, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.9 PRESSURE GAUGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AMETEK, Inc.
 2. Ashcroft Inc.
 3. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gauge Range: Zero to 300 psig.
- E. Water System Piping Gauge: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

- A. Connect fire-suppression standpipe piping to water-service piping at service entrance into building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping."
- B. Install shutoff valve, pressure gauge, drain, and other accessories at connection to fire-suppression water-service piping.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.
- C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
- D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install drain valves on standpipes. Extend drain piping to outside of building.
- F. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.
- G. Install alarm devices in piping systems.
- H. Install hangers and supports for standpipe system piping in accordance with NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

- I. Install pressure gauges on riser or feed main and at top of each standpipe. Include pressure gauges with connection of not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.
- J. Fill wet-type standpipe system piping with water.
- K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- C. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.
- D. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- E. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts in accordance with ASME B31.9.
- F. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe in accordance with AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings in accordance with AWWA C606 for steel-pipe joints.
- G. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe in accordance with AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings in accordance with AWWA C606 for steel-pipe grooved joints.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties in accordance with NFPA 14, authorities having jurisdiction and manufacturer's instructions.
- B. Install listed fire-protection supervised-open shutoff valves, located to control sources of water supply, except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection.
- D. Specialty Valves:
 1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 2. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.

3.6 HOSE-CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes.
- B. Install freestanding hose connections for access and minimum passage restriction.
- C. Install NPS 1-1/2 hose-connection valves with flow-restricting device.
- D. Install NPS 2-1/2 hose connections with flow-restricting device.
- E. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

3.7 HOSE-STATION INSTALLATION

- A. Install freestanding hose stations for access and minimum passage restriction.
- B. Install freestanding hose stations with support or bracket attached to standpipe.

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

3.8 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping in accordance with NFPA 14 requirements.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect standpipe systems in accordance with NFPA 14, "System Acceptance" chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Start and run air compressors.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.
 - 8. Verify that equipment hose threads are same as local fire-department equipment.
- C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.11 PIPING SCHEDULE

- A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.
- B. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 4 and smaller, shall be one of the following:
 - 1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Schedule 40, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- C. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 5 to NPS 8, shall be[one of] the following:
 - 1. Schedule 30, black-steel pipe with or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 2. Schedule 40, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.

END OF SECTION 211200

SECTION 211213 - FIRE-SUPPRESSION HOSES AND NOZZLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. NPS 1-1/2 rack-type hose stations.

B. Related Requirements:

1. Section 104413 "Fire Protection Cabinets" for hose cabinets.
2. Section 211200 "Fire-Suppression Standpipes" for fire hose valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 NPS 1-1/2 RACK-TYPE HOSE STATIONS

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

1. American Fire Hose & Cabinet.
2. Elkhart Brass Mfg. Co., Inc.
3. Fire-End & Croker Corporation.
4. Potter Roemer LLC; a Division of Morris Group International.
5. Viking Corporation.

B. Hose Rack:

1. Standard: UL 47.
2. Material: Steel with red-enamel finish.
3. Type: Hose-rack assembly. Include hose valve, hose rack, water-retention device, hose pins, and hose.
4. Operation: Semiautomatic.
5. Sized to hold fire hose.

C. Hose Valve:

1. Standard: UL 668, NPS 1-1/2, for connecting fire hose.
2. Type: Adjustable.
3. Hose Valve and Trim Finish: Rough brass or bronze.
4. Pressure Rating: 300 psig minimum.
5. Pattern: Angle.
6. Material: Brass or bronze.
7. Pressure-Control Device: UL 1468 integral or for field installation if indicated.
8. Size: NPS 1-1/2.
9. Inlet: Female pipe threads.
10. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.

D. Hose:

1. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
2. Size: NPS 1-1/2.
3. Length: 100 feet.
4. Jacket: Synthetic thread.
5. Lining: Rubber, plastic, or combination of rubber and plastic compounds.
6. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
7. Nozzle: UL 401.
 - a. Material: Brass.
 - b. Type: Spray, adjustable from shutoff to fog spray or straight stream

PART 3 - EXECUTION

3.1 HOSE-STATION INSTALLATION

- A. Install freestanding hose stations for access and minimum passage restriction.
- B. Install NPS 1-1/2 hose-station valves with flow-restricting device unless otherwise indicated.
- C. Install freestanding hose stations with support or bracket attached to standpipe.

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

END OF SECTION 211213

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Specialty valves.
3. Sprinklers.
4. Pressure gauges.

B. Related Requirements:

1. Section 211119 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
2. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, or BIM model, drawn to scale, on which items of other systems and equipment are shown and coordinated with each other, using input from installers of the items involved.

B. Qualification Data: For qualified Installer.

C. Design Data:

1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
 - D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
 - E. Field quality-control reports.
- 1.4 CLOSEOUT SUBMITTALS
- A. Operation and maintenance data.
- 1.5 QUALITY ASSURANCE
- A. Installer Qualifications:
 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

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. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with NFPA 13.
- C. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
 1. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
 - b. Sprinkler Occupancy Hazard Classifications:
 - 1) Building Service Areas: Ordinary Hazard, Group 1.

- 2) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - 3) Elevator Machine Room and Hoistway: Ordinary Hazard, Group 1.
 - 4) General Storage Areas: Ordinary Hazard, Group 1.
 - 5) Libraries except Stack Areas: Light Hazard.
 - 6) Library Stack Areas: Ordinary Hazard, Group 2.
 - 7) Machine Shops: Ordinary Hazard, Group 2.
 - 8) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - 9) Classroom, Office and Public Areas: Light Hazard.
 - 10) Restaurant Service Areas: Ordinary Hazard, Group 1.
2. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
 - c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
 3. Maximum Protection Area per Sprinkler:
 - a. Classroom and Office Spaces: 225 sq. ft.
 - b. Storage Areas: 130 sq. ft.
 - c. Mechanical Equipment Rooms: 130 sq. ft.
 - d. Electrical Equipment Rooms: 130 sq. ft.
 - e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
- E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- ## 2.2 STEEL PIPE AND FITTINGS
- A. Standard-Weight, Black-Steel Pipe: ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
 - B. Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
 - C. Uncoated-Steel Couplings: ASTM A865/A865M, threaded.
 - D. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
 - E. Malleable- or Ductile-Iron Unions: UL 860.
 - F. Cast-Iron Flanges: ASME 16.1, Class 125.
 - G. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
 - b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

H. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Shurjoint-Apollo Piping Products USA Inc.
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.
2. Pressure Rating: 175-psig minimum.
3. Painted or Uncoated Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Specialty Valves Pressure Rating: 175-psig minimum.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Alarm Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.

- e. Viking Corporation.
 - 2. Standard: UL 193.
 - 3. Design: For horizontal or vertical installation.
 - 4. Drip cup assembly pipe drain with check valve to main drain piping.
- G. Automatic (Ball Drip) Drain Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco by Johnson Controls Company.
 - 2. Standard: UL 1726.
 - 3. Pressure Rating: 175-psig minimum.
 - 4. Type: Automatic draining, ball check.
 - 5. Size: NPS 3/4.
 - 6. End Connections: Threaded.

2.4 AIR VENT

A. Manual Air Vent/Valve:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. National Fittings, Inc.
 - c. Shurjoint-Apollo Piping Products USA Inc.
 - d. Victaulic Company.
- 2. Description: Ball valve that requires human intervention to vent air.
- 3. Body: Forged brass.
- 4. Ends: Threaded.
- 5. Minimize Size: 1/2 inch.
- 6. Minimum Water Working Pressure Rating: 300 psig.

2.5 SPRINKLER PIPING SPECIALTIES

A. Flow Detection and Test Assemblies:

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

- a. AGF Manufacturing, Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco by Johnson Controls Company.
 - d. Victaulic Company.
 2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 3. Pressure Rating: 175-psig minimum.
 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded or grooved.
- B. Branch Line Testers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Elkhart Brass Mfg. Co., Inc.
 - c. Fire-End & Croker Corporation.
 - d. Potter Electric Signal Company, LLC.
 - e. Potter Roemer LLC; a Division of Morris Group International.
 2. Standard: UL 199.
 3. Pressure Rating: 175 psig.
 4. Body Material: Brass.
 5. Size: Same as connected piping.
 6. Inlet: Threaded.
 7. Drain Outlet: Threaded and capped.
 8. Branch Outlet: Threaded, for sprinkler.
- C. Sprinkler Inspector's Test Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Tyco by Johnson Controls Company.
 - c. Victaulic Company.
 - d. Viking Corporation.
 2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 3. Pressure Rating: 175-psig minimum.
 4. Body Material: Cast- or ductile-iron housing with sight glass.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.

D. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aegis Technologies, Inc.
 - b. CECA, LLC.
 - c. CPS Products, Inc.
 - d. Merit Manufacturing.
2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

E. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FlexHead Industries, Inc.
 - b. Gateway Tubing, Inc.
 - c. Victaulic Company.
2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175-psig minimum.
5. Size: Same as connected piping, for sprinkler.

2.6 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Globe Fire Sprinkler Corporation.
 2. Reliable Automatic Sprinkler Co., Inc. (The).
 3. Tyco by Johnson Controls Company.
 4. Victaulic Company.
 5. Viking Corporation.
- B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

- D. Automatic Sprinklers with Heat-Responsive Element:
 - 1. Nonresidential Applications: UL 199.
 - 2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- E. Sprinkler Finishes: Chrome plated and factory-painted.
- F. Special Coatings: Wax and corrosion-resistant paint.
- G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment and Plastic, white finish, one piece, flat.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- H. Sprinkler Guards:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco by Johnson Controls Company.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - 2. Standard: UL 199.
 - 3. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 PRESSURE GAUGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AGF Manufacturing, Inc.
 - 2. AMETEK, Inc.
 - 3. Ashcroft Inc.
 - 4. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gauge Range: 0 to 300 psig.

- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.
- B. Install shutoff valve, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

3.2 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 (and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.
- N. Fill sprinkler system piping with water.
- O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection.
- D. Specialty Valves:
 - 1. Install valves in vertical position for proper direction of flow, in main supply to system.
 - 2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
- E. Air Vent:
 - 1. Provide at least one air vent in each wet pipe sprinkler system in accordance with NFPA 13 requirements. Connect vent into top of fire sprinkler piping.

2. Provide dielectric union for dissimilar metals, ball or globe valve, and strainer upstream of automatic air vent.

3.5 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.
- B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.6 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 4. Energize circuits to electrical equipment and devices.
 5. Coordinate with fire-alarm tests. Operate as required.
 6. Coordinate with fire-pump tests. Operate as required.
 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 CLEANING

- A. Clean dirt and debris from sprinklers.

- B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.9 PIPING SCHEDULE

- A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- B. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.10 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Special Applications: Extended-coverage sprinklers where indicated.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - 2. Upright, Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

SECTION 213216 - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical-turbine fire pumps with diesel-engine drives.
2. Fire-pump accessories and specialties.
3. Fuel oil storage.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire pumps, right-angle gear drives, engine drivers, and fire-pump accessories and specialties.

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

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

B. Product Certificates: For each type of fire pump.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire pumps 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. Environmental Conditions:
 - 1. Ambient Temperature: 40 to 104 deg F.
 - 2. Relative Humidity: Zero to 95 percent.
 - 3. Altitude: Sea level to 1000 feet.

2.2 ASSEMBLY DESCRIPTION

- A. Description: Factory-assembled and -tested fire pump, right-angle gear drive, and driver.
- B. NFPA Compliance: Comply with NFPA 20.
- C. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver, with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.
- D. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- E. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 VERTICAL-TURBINE FIRE PUMPS

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

1. A-C Fire Pump; a Xylem brand.
 2. Aurora Pump; Pentair Ltd.
 3. Patterson Pump Company; a Gorman-Rupp company.
 4. Peerless Pump Company.
 5. S.A. Armstrong Limited.
- B. Pump Head: Cast iron, for surface discharge.
1. Discharge Outlet: With flange according to ASME B16.1, except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
 2. Pump Head Seal: Stuffing box and packing.
 3. Base: Cast iron or steel with hole for electrical cable.
- C. Pump:
1. Standard: UL 448, for vertical-turbine pumps for fire service.
 2. Discharge Head: High-profile cast iron or steel with flanged, aboveground, outlet Class 125 for cast iron and Class 150 for steel, with NPS 1/2, threaded, pressure-gage connection.
 3. Stuffing Box: Cast iron with packing rings, pressure relief connection, stainless-steel packing gland, bronze bearing, and rubber slinger.
 4. Line Shaft: Stainless steel in sections 10 feet or less, with left-hand threaded-steel couplings, centering spiders, and fluted rubber bearings.
 5. Line Shaft Bearings: Bronze, water lubricated.
 6. Bowl Section:
 - a. Multiple close-grained, flanged cast-iron bowls.
 - b. Intermediate bowls with enamel-lined waterways for maximum efficiency and wear protection and of identical design for interchangeability.
 - c. Bowls fitted with bronze bearings.
 7. Impeller: Closed-type silicon bronze dynamically balanced and securely fastened to bowl.
 8. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.
 9. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the impeller surface.
 10. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections 10 feet or less.
 11. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of 1/2-inch spheres.
- D. Right-Angle Gear Drive: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.
- E. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.

F. Capacities and Characteristics:

1. See drawing schedule.

2.4 DIESEL-ENGINE DRIVER

A. Fuel: Fuel oil, Grade DF-2.

B. Horse Power Rating: Not less than 110 percent of maximum brake horsepower (after derating for temperature and elevation according to NFPA 20).

C. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.

D. Controls:

1. Adjustable governor.
2. Over-speed shutdown.
3. Manual reset, speed switch.
4. Instrument panel with tachometer, oil pressure gage, water temperature gage, and hour meter.

E. Fuel System:

1. Comply with NFPA 20.
2. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
3. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
4. Flexible metallic fuel lines.
5. Inline fuel filter.
6. Oil pressure safety switch.
7. Air cleaner.
8. Engine-driven oil pump.
9. Enclosed control wiring electric starter with voltage regulator.
10. Double-Wall Storage Tank: Size indicated, but not less than required by NFPA 20; with floor legs, direct-reading level gage, and secondary containment tank having capacity at least equal to storage tank.

F. Exhaust System:

1. Piping: ASTM A53/A53M, Type E or S, Schedule 40 black steel pipe; ASME B16.9 weld-type pipe fittings; ASME B16.5 steel flanges; and ASME B16.21 nonmetallic gaskets.
2. Fabricate double-wall, ventilated thimble from steel pipe.
3. Flexible exhaust connector.

4. Industrial exhaust silencer with spark arrestor.
- G. Rated Engine Speed: 1800 rpm.
- H. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.
- I. Engine- or Skid-Mounted Lubrication System:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Controls 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.
- J. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system.
- K. Cooling System:
1. Factory-installed, closed loop, liquid cooled, with radiator factory mounted on fire-pump mounting frame and integral engine-driven coolant pump.
 2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 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-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig maximum working pressure, with coolant at 180 deg F, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- L. Muffler/Silencer: Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 18 dB at 500 Hz.
 2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 95 dBA or less.
- M. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

N. Starting System: 12-V dc, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Adequate capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 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.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. 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 deg C 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. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
- B. Relief Valves: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
- C. Outlet Fitting: Concentric tapered reducer at pump-head-discharge outlet.
- D. Discharge Cone: Closed or open type.

E. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A53/A53M, Schedule 40 galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4 galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: Complying with UL 1726.
5. Manifold:
 - a. Test Connections: Comply with UL 405, except provide outlets without clappers instead of inlets.
 - b. Body: Exposed-type, brass or ductile iron, with number of outlets required by NFPA 20.
 - c. Escutcheon Plate: Brass or bronze; rectangular.
 - d. Exposed Parts Finish: Rough brass.
 - e. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.6 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Day Tank: UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin, with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
2. Tank Capacity: As recommended by engine manufacturer.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.7 GROUT

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

2.8 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - 1. Verification of Performance: Rate fire pumps according to UL 448.
- B. Fire pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps 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. Attach pumps to equipment base using anchor bolts.
 - 3. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- C. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
- D. Support piping and pumps separately, so weight of piping does not rest on pumps.

- E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes." And Section 211313 "Wet-Pipe Sprinkler Systems."
- F. Install pressure gages on fire-pump suction and discharge flange pressure-gageappings. Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes."
- G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
- H. Install fuel system according to NFPA 20.
- I. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
- J. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.
- K. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
- L. Electrical Wiring: Install electrical devices furnished by equipment manufacturers that are not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
- M. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- N. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- O. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- P. Align piping connections.
- Q. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.
- R. Comply with requirements for piping and valves specified in Section 211200 "Fire-Suppression Standpipes." and Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.
- S. Install piping adjacent to pumps and equipment to allow service and maintenance.

- T. Connect relief-valve discharge to drainage piping or point of discharge.
- U. Connect fire pumps to their controllers.
- V. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.2 FIELD QUALITY CONTROL

- A. Test each fire pump with its right-angle gear drive and controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
 - 2. Test according to NFPA 20 for acceptance and performance testing.
 - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.3 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 213216

SECTION 213413 - PRESSURE-MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Regenerative-turbine, pressure-maintenance pumps.
2. Vertical-turbine, pressure-maintenance pumps.

B. Related Requirements:

1. Section 262933 "Controllers for Fire-Pump Drivers" for pressure-maintenance-pump controllers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For pumps, accessories, and specialties.

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

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 VERTICAL-TURBINE, PRESSURE-MAINTENANCE PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. A-C Fire Pump; a Xylem brand.
 2. Aurora Pump; Pentair Ltd.
 3. Patterson Pump Company; a Gorman-Rupp company.
 4. Peerless Pump Company.
 5. S.A. Armstrong Limited.
- B. Description: Factory-assembled and -tested, vertical, multistage, open-line-shaft turbine pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted above pump head.
- C. Pump Construction:
1. Pump Head: Cast iron, for surface discharge, with flange except connections may be threaded in sizes in which flanges are not available.
 2. Pump Head Seal: Stuffing box and stuffing.
 3. Line Shaft: Steel.
 4. Line Shaft Bearings: Corrosion resistant, oil lubricated.
 5. Impeller Shaft: Monel metal or stainless steel.
 6. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
 7. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet or less, with strainer of cast or fabricated bronze or stainless steel at bottom.
- D. 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.
- E. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
1. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet long.
- F. Base: Cast iron or steel with hole for electrical cable.
- G. Nameplate: Permanently attached to pump and indicating capacity and characteristics.
- H. Capacities and Characteristics:
1. See drawing schedule.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
 - 1. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.
- B. Equipment Mounting:
 - 1. Install vertical-turbine, pressure-maintenance pumps according to HI 2.4.
 - 2. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - a. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
 - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - e. Attach pumps to equipment base using anchor bolts.
 - f. Shim pumps as needed to make them level.
 - 3. Install isolation valves in both inlet and outlet pipes near the pump. Comply with requirements for valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.3 ADJUSTING

- A. Lubricate pumps as recommended by manufacturer.
- B. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 213413

SECTION 220516 – EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packless expansion joints.
2. Alignment guides and anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: 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.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

- A. Rubber Union Connector Expansion Joints:
 - 1. Material: Twin reinforced-rubber spheres with external restraining cables.
 - 2. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
 - 3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- B. Flexible-Hose Packless Expansion Joints:
 - 1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - 2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 - 3. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 - 4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
 - 5. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.

6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with [flanged] [welded] end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.

C. Externally Pressurized Metal-Bellows Packless Expansion Joints:

1. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
2. Description:
 - a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
 - b. Carbon-steel housing.
 - c. Drain plugs and lifting lug for NPS 3 (DN 80) and larger.
 - d. Joint Axial Movement: 4 inches (100 mm) of compression and 0.75 inch (19 mm) of extension.
3. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
4. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 INSTALLATION OF ALIGNMENT-GUIDES AND ANCHORS

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
1. Anchor Attachment to Steel Structural Members: Attach by welding.
 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 220516

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 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: Carbon steel.
 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

2.5 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- 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 1-inch (25-mm) 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 (50 mm) above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- 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 (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) 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 (50 mm) 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 grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, 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.

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Cast-iron wall sleeves, or Galvanized-steel wall sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:

- a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
- 5. Interior Partitions:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- 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 piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
- c. Insulated Piping: One-piece, stamped-steel type.
- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
- f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
- h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
- j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
- k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

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: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bimetallic-actuated thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.
 - 4. Gage attachments.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) nominal diameter.

- C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
- D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- E. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
- F. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
- G. Window: Plain glass or plastic.
- H. Ring: Stainless steel.
- I. Element: Bimetal coil.
- J. Pointer: Dark-colored metal.
- K. Accuracy: Plus or minus 1 percent of scale range.

2.2 THERMOWELLS

- A. Thermowells:
 - 1. Standard: ASME B40.200.
 - 2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 - 3. Material for Use with Copper Tubing: CNR or CUNI.
 - 4. Material for Use with Steel Piping: CRES.
 - 5. Type: Stepped shank unless straight or tapered shank is indicated.
 - 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1 (DN 15, DN 20, or NPS 25), ASME B1.20.1 pipe threads.
 - 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
 - 8. Bore: Diameter required to match thermometer bulb or stem.
 - 9. Insertion Length: Length required to match thermometer bulb or stem.
 - 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
 - 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.3 PRESSURE GAGES

- A. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
 - 1. Standard: ASME B40.100.
 - 2. Case: Sealed type; plastic; 4-1/2-inch (114-mm) nominal diameter.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
 7. Pointer: Dark-colored metal.
 8. Window: Glass or plastic.
 9. Accuracy: Grade D, plus or minus 5 percent of whole scale range.
- B. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install thermometers in the following locations:
 1. Inlet and outlet of each water heater.

2. Inlet and outlet of each domestic hot-water storage tank.

K. Install pressure gages 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.

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

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

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be the following:

1. Liquid-filled, bimetallic-actuated type.

B. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be the following:

1. Liquid-filled, bimetallic-actuated type.

C. Thermometer stems shall be of length to match thermowell insertion length.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).

B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C).

3.4 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be one of the following:

1. Liquid-filled, direct-mounted, plastic-case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:

1. Liquid-filled, direct-mounted, plastic-case.

C. Pressure gages at suction and discharge of each domestic water pump shall be the following:

1. Liquid-filled, direct-mounted, plastic-case.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 100 psi (0 to 600 kPa.

END OF SECTION 220519

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

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

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

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

G. Valve Actuator Types:

1. Handlever: For quarter-turn valves smaller than NPS 3.

H. Valves in Insulated Piping:

1. Include 2-inch (50-mm) stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. CWP Rating: 600 psig (4140 kPa).
 - c. Body Design: Two piece.
 - d. Body Material: Bronze.
 - e. Ends: Threaded and soldered.
 - f. Seats: PTFE.
 - g. Stem: Bronze or brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.

B. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Press Ends:

1. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. CWP Rating: Minimum 200 psig (1380 kPa).
 - c. Body Design: Two piece.
 - d. Body Material: Bronze.
 - e. Ends: Press.
 - f. Press Ends Connections Rating: Minimum 200 psig (1380 kPa).
 - g. Seats: PTFE or RTPFE.
 - h. Stem: Bronze or brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.
 - k. O-Ring Seal: EPDM or Buna-N.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.

3.2 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. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Brass ball valves, two-piece with full port and brass trim. Provide with threaded, solder, or press connection-joint ends.

END OF SECTION 220523.12

SECTION 220523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B16.1 for flanges on iron valves.
 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 3. ASME B31.9 for building service piping valves.
- C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types:
1. Handlever: For valves NPS 6 (DN 150) and smaller.
 2. Chainwheel: Device for attachment to gear, handlever, or stem; of size and with chain for mounting height, according to "Valve Installation" Article.

- G. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:

1. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - e. Seat: EPDM.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Aluminum bronze.

2.3 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.
 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 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.

3.3 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.

END OF SECTION 220523.13

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING.

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze swing check valves.
2. Iron swing check valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

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

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.

2.2 BRONZE SWING CHECK VALVES

- A. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:

1. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: TFE.

2.3 IRON SWING CHECK VALVES

- A. Iron Swing Check Valves with Metal Seats, Class 125:

1. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A126, gray iron with bolted bonnet.
 - e. Ends: Flanged or threaded. See valve schedule articles.
 - f. Trim: Bronze.
 - g. Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.

- E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
 - b. NPS 2-1/2 (DN 65) and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; metal-seat check valves.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. End Connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded or soldered or press-ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
 - 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze swing check valves bronze disc, Class 125, with soldered, threaded or press end connections.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Iron swing check valves with metal seats, Class 125, with threaded or flanged end connections.

END OF SECTION 220523.14

SECTION 220523.15 - GATE VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B16.18 for solder joint.
 5. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- 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.

2.2 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:

1. Description:

- a. Standard: MSS SP-80, Type 1.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: Bronze with integral seat and screw-in bonnet.
- d. Ends: Threaded or solder joint.
- e. Stem: Bronze.
- f. Disc: Solid wedge; bronze.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 125:

1. Description:

- a. Standard: MSS SP-70, Type I.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: Gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: Bronze.
- f. Disc: Solid wedge.
- g. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

- 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
- 2. Chain: Hot-dip galvanized steel of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for gate valves [NPS 4 (DN 100)] <Insert size> and larger and more than [96 inches (2400 mm)] <Insert dimension> above floor. Extend chains to [60 inches (1520 mm)] <Insert dimension> above finished floor.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. Use gate valves for shutoff service only.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze gate valves, NRS, Class 125 with soldered, threaded or press fit ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, NRS, Class 125 with flanged ends.

END OF SECTION 220523.15

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
2. Section 220548 "Vibration and Seismic 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.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

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

- B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 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 pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

- 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.

2.4 THERMAL HANGER-SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: ASTM C552, Type II cellular glass with 100-psig (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

2.6 PIPE-POSITIONING SYSTEMS

- A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.7 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

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 (34.5-MPa), 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 shall be weight of supported components plus 200 lb (90 kg).

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. 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 from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. 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 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. 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.
- M. Insulated Piping:
 1. Attach clamps and spacers to piping.
 - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.

- c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
- 2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
- 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) 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 (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) 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.
- 6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 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 because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 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 (40 mm).

3.6 PAINTING

- A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 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 carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal hanger-shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C) pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction occurs.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction occurs.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. 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.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- R. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 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. Snubbers.
13. Restraints - rigid type.
14. Restraints - cable type.
15. Restraint accessories.
16. Post-installed concrete anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated-Design Submittal:

1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, and concrete anchor and insert, that is required by this Section or is indicated on Drawings, submit the following:

- a. Seismic and wind-load restraint, and vibration isolator, and isolation base selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
 - c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
 - d. Seismic Design Calculations: Submit all input data and loading calculations prepared in "Performance Requirements" Article in "Seismic Design Calculations" Paragraph.
 - e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared in "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
 - f. Qualified Professional Engineer: All designated-design submittals for seismic and wind-load-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
2. Seismic-and Wind-Load-Restraint Detail Drawing:
 - 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 and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES and an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
4. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation and wind-load reinforcement device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Welding certificates.
- C. Field quality-control reports:
- D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-10 Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
 - 1. Provide equipment manufacturer's written certification for each designated active plumbing seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction.
 - 2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-10.
 - 3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
- E. Wind-Force Performance Certification: Provide special certification for plumbing components subject to high wind exposure and impact damage.
 - 1. Provide equipment manufacturer's written certification for each designated plumbing device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
 - 2. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

- C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to 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: ICC-ES product listing an agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind-load control system.
 - 1. Seismic and Wind-Load Performance: Equipment shall withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7-10.
- B. Seismic Design Calculations:
 - 1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-10 including supplement No. 1 or other seismic calculation method required by authorities having jurisdiction. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the section text.
 - a. Data indicated below to be determined by Delegated-Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
 - c. Building Occupancy Category: IV.
 - d. Building Risk Category: IV.
 - e. Building Site Classification: D.
 - 2. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise noted. Any factors not listed shall be obtained by the Delegated-Design Contractor for each component.
 - a. Horizontal Seismic Design Force F_p : Value is to be calculated by Delegated-Design Contractor using Equation 13.3-1. Factors below must be obtained by Delegated-Design Contractor for this calculation.

- 1) S_{DS} = Spectral Acceleration: 0.674. Value applies to all components on Project.
 - 2) a_p = Component Amplification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 3) I_p = Component Importance Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from each component.
 - 5) R_p = Component Response Modification Factor: Obtain by Delegated-Design Contractor from each component.
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determine from Project Drawings for each component by Delegated-Design Contractor. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
- b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.
- c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
- 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated-Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A
 - 4) δ_{yA} = Deflection at Building Level y of Structure A
 - 5) δ_{yB} = Deflection at Building Level y of Structure B
 - 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 8) Δ_{aA} = Allowable Story Drift for Structure A
 - 9) Δ_{aB} = Allowable Story Drift for Structure B
 - 10) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a
- d. Component Fundamental Period T_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:
- 1) W_p = Component Operating Weight: Determined by Contractor from Project Drawings and manufacturer's data.

- 2) g = Gravitational Acceleration: 32.17 fps^2 (9.81 m/s^2).
 - 3) K_p = Combined Stiffness of the Component, Supports, and Attachments: Determined by delegated-design seismic engineer.
3. Calculation Factors, ASCE/SEI 7-10, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-10 unless otherwise noted.
- a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-10, Equation 13.3-1. Factors below must be obtained by Delegated-Design Contractor for this calculation:
 - 1) S_{DS} = Spectral Acceleration
 - 2) a_p = Component Amplification Factor
 - 3) I_p = Component Importance Factor
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from equipment submittal.
 - 5) R_p = Component Response Modification Factor
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determined from Project Drawings for each component by Contractor. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
 - b. Vertical Seismic Design Force: Calculate by Delegated- Design Contractor using method explained in ASCE/SEI 7-10, Paragraph 13.3.1.
 - c. Seismic Relative Displacement D_p : Calculate by Delegated-Design Contractor using methods explained in ASCE/SEI 7-10, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
 - 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculate by Delegated-Design Contractor in accordance with ASCE/SEI 7-10, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A
 - 4) δ_{yA} = Deflection at Building Level y of Structure A
 - 5) δ_{yB} = Deflection at Building Level y of Structure B
 - 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data;
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 8) Δ_{aA} = Allowable Story Drift for Structure A
 - 9) Δ_{aB} = Allowable Story Drift for Structure B
 - 10) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a

4. Calculation Factors, ASCE/SEI 7-05, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-05 unless otherwise noted.
 - a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-05, Equation 13.3-1. Factors below must be obtained for this calculation.
 - 1) S_{DS} = Spectral Acceleration
 - 2) a_p = Component Amplification Factor
 - 3) I_p = Component Importance Factor
 - 4) W_p = Component Operating Weight: Obtain by Delegated-Design Contractor for each component from component submittal.
 - 5) R_p = Component Response Modification Factor
 - 6) z = Height in Structure of Point of Attachment of Component for the Base: Determine by Delegated-Design Contractor for each component from Project Drawings. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for the Base: Determine by Delegated-Design Contractor from Project Drawings.
 - b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-05, Paragraph 13.3.1.
 - c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-05, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
 - 1) δ_{xA} = Deflection at Building Level x of Structure A
 - 2) δ_{yA} = Deflection at Building Level y of Structure A
 - 3) δ_{yB} = Deflection at Building Level y of Structure B
 - 4) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 5) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 6) Δ_{aA} = Allowable Story Drift for Structure A
 - 7) Δ_{aB} = Allowable Story Drift for Structure B
 - 8) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a : Obtain by Delegated-Design Contractor from each component.

C. Wind-Load Design Calculations:

1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-10 or other wind-force calculation method required by authorities having jurisdiction. Where

"ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise noted.

- a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
2. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-16, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
- a. Risk Category: IV.
 - b. h = Mean Roof Height: Determine by Delegated-Design Contractor from Project Drawings.
 - c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI) K_d = Wind Directionality Factor: 0.85.
 - d. Exposure Category: D.
 - e. K_{zt} = Topographic Factor: 1.0.
 - f. K_e = Ground Elevation Factor: 1.0.
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.
 - h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor
 - i. q_z = Velocity Pressure: Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - j. q_h = Velocity Pressure: Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor
 - l. Enclosure Classification: To be determined by Delegated-Design Contractor.
 - m. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
3. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-10, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.

- a. Risk Category: IV.
 - b. h = Mean Roof Height: To be determined by Delegated-Design Contractor from the Project Drawings.
 - c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI)
 - d. K_d = Wind Directionality Factor: 0.85.
 - e. Exposure Category: D.
 - f. K_{zt} = Topographic Factor: 1.0.
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.
 - h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor.
 - i. q_z = Velocity Pressure at Height z : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - j. q_h = Velocity Pressure at Height h : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor.
 - l. Enclosure Classification: To be determined by Delegated-Design Contractor.
 - m. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
4. Design Wind Force "F" for rooftop equipment and external sidewall-mounted equipment such as louvers is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-05, Ch. 6.
- a. I = Importance Factor: 1.0 or 1.5 To be determined by Delegated-Design Contractor.
 - b. h = Mean Roof Height: To be determined by Delegated-Design Contractor by reviewing the plans.
 - c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI)
 - d. K_d = Wind Directionality Factor: 0.85.
 - e. Exposure Category: D.
 - f. K_{zt} = Topographic Factor: 1.0
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.

- h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor.
 - i. q_z = Velocity Pressure at Height z : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source approved by authorities having jurisdiction.
 - j. q_h = Velocity Pressure at Roof Height h : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor.
 - l. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
 - m. GC_p = External pressure coefficient: To be determined by Delegated-Design Contractor.
 - n. C_f = Force Coefficient: Value determined by delegated wind-load design Contractor from ASCE/SEI 7-05, Figures 6-21 through 6-23 or other source approved by authorities having jurisdiction.
 - o. A_f = Projected area normal to the wind: except where C_f is specified for the actual surface area. Value determined by delegated wind-load design contractor from equipment submittal or manufacturer.
- D. Consequential Damage: Provide additional seismic and wind-force restraints for suspended plumbing components or anchorage of floor, roof or wall mounted plumbing components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential plumbing component will not cause the failure of any other essential architectural, mechanical or electrical building component.
- E. Fire/Smoke Resistance: Seismic- and wind-load-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 an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- F. Component Supports:
- 1. Load Ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
 - 2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6

2.2 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. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
4. Surface Pattern: Smooth, ribbed, or waffle pattern.
5. Load-bearing metal plates adhered to pads.
6. Sandwich-Core Material: Resilient and elastomeric.
 - a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts

1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts

1. Description: All-directional isolator with seismic 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.

2.5 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 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 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. 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 psig (3447 kPa).
 - b. Top housing with attachment and leveling bolt.

2.7 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 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

1. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
2. 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 psig (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- (13-mm-) 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 psig (3447 KPa) on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- (13-mm-) 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.

2.11 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
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. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC. Preset concrete inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
2. Anchors in Masonry: Design in accordance with TMS 402.
3. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
4. Resilient Cushion: Maximum 1/4-inch (6-mm) air gap, and minimum 1/4 inch (6 mm) thick.

2.14 RESTRAINTS - RIGID TYPE

- A. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, 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.

2.15 RESTRAINTS - CABLE TYPE

- A. Seismic- and Wind-Load-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. All 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.

2.16 RESTRAINT ACCESSORIES

- 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.

2.17 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 - 1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

- B. Provide post-installed concrete anchors that have been prequalified for use in seismic applications.
 - 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.
- C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW), which is not vibration isolated.
 - 1. Undercut expansion anchors are permitted.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction].
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static, wind load, and seismic load within specified loading limits.

3.2 INSTALLATION OF VIBRATION CONTROL, WIND-LOAD CONTROL, AND SEISMIC-RESTRAINT 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. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- C. 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."

- D. Installation of vibration isolators, wind-load restraints, and seismic restraints must not cause any stresses, misalignment, or change of position of equipment or piping.
- 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).
 - 3. Install seismic-restraint and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction] that provides required submittals for component.
- F. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- G. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.
- H. Install seismic- and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- J. 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.
- K. 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.
- L. 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 Project 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 shall be installed with sleeve fully engaged in the structural element to which anchor is to 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.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Provide flexible connections in piping systems where they cross structural seismic joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 1. Perform tests and inspections with the assistance of a factory-authorized service representative.
 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 3. 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.
 4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 6. Test to 90 percent of rated proof load of device.
 7. Measure isolator restraint clearance.

8. Measure isolator deflection.
 9. Verify snubber minimum clearances.
 10. Test and adjust restrained-air-spring isolator controls and safeties.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 220548

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. Pipe labels.

B. Related Requirements:

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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch (0.8-mm) 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 (64 by 19 mm).
4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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 (1.6 mm) 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 (71 deg C).
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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 (1.6 mm) 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 (71 deg C).
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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, and other applicable codes and standards.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 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 partially cover 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[main] distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

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 are-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

- B. 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. (1 m) 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. (1 m) of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 15 ft. (8 m) along each run. Reduce intervals to 7 ft. (3 m) in areas of congested piping and equipment.

- C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F (52 deg C) or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

- D. Flow-Direction Flow 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.

E. 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 colors.
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.
5. Nonpotable Cold Water: Black letters on an ANSI Z535.1 safety-yellow background.

END OF SECTION 220553

SECTION 220593 - TESTING, ADJUSTING, AND BALANCING FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. 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.
 - c. Sanitary sewage pumps.
 - d. Drainage pumps.
3. Pipe-leakage test verification.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 90 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 90 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
- C. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

- D. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.4 QUALITY ASSURANCE

- A. TAB Specialists Qualifications, Certified by AABC, NEBB or TABB:
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE 188 Compliance: Comply with balancing and report requirements, Section 8.3 "Balancing."
- D. Code and Authorities Having Jurisdiction Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.5 FIELD CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, and balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine approved submittals for plumbing systems and equipment.
- D. Examine design data, including plumbing system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about plumbing system and equipment controls.
- E. Examine equipment performance data, including pump curves.
 - 1. Relate performance data to Project conditions and requirements, including pump system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate pump system-effect factors to reduce performance ratings of plumbing equipment when installed under conditions different from the conditions used to rate equipment performance. Compare results with the design data and installed conditions.
- F. Examine system and equipment installations, and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine plumbing equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- I. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainers are installed and clean.
- J. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- K. Examine system pumps to ensure absence of entrained air in the suction piping.

- L. Examine operating safety interlocks and controls on plumbing equipment.
- M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Domestic Water System:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
 - b. Water heaters are installed and functioning.
 - c. Piping is complete and all points of outlet are installed.
 - d. Water treatment is complete.
 - e. Systems are flushed, filled, and air purged.
 - f. Strainers are clean.
 - g. Control valves are functioning in accordance with the sequence of operation.
 - h. Shutoff and balance valves are 100 percent open.
 - i. Booster- and hot-water circulating pumps are operational and proper rotation is verified.
 - j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - k. Variable-frequency controllers' startup is complete and safeties are verified.
 - l. Suitable access to balancing devices and equipment is provided.
 - 2. Sanitary Sewage/Drainage System:
 - a. Leakage and pressure tests on sanitary sewage/drainage systems have been completed in accordance with applicable code and authority having jurisdiction requirements.
 - b. Piping is complete.
 - c. Sanitary sewage pumps/drainage pumps are operational.
 - d. Control valves are functioning in accordance with the sequence of operation.
 - e. Shutoff valves are 100 percent open.

- f. Suitable access to equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 220716 "Plumbing Equipment Insulation" and Section 220719 "Plumbing Piping Insulation."
- C. Mark equipment and balancing devices, including valve position indicators and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR PLUMBING EQUIPMENT

- A. Test, adjust, and balance plumbing equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Domestic water booster pumps.
 - 3. Domestic water in-line pumps.
 - 4. Domestic water heaters.
 - 5. Sanitary sewage pumps.
 - 6. Drainage pumps.

3.5 PROCEDURES FOR DOMESTIC WATER SYSTEMS

- A. Prepare test reports for pumps and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required equipment flow rates with system design flow rates.
- B. Prepare schematic diagrams of systems' Record drawings piping layouts.

- C. In addition to requirements in "Preparation" Article, 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. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 - 6. Verify that motor controllers are equipped with properly sized thermal protection.
 - 7. Check that air has been purged from the system.
- D. Measure and record upstream and downstream pressure of each piece of equipment.
- E. Measure and record upstream and downstream pressure of pressure-reducing valves.
- F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- G. Check settings and operation of each safety valve. Record settings.

3.6 PROCEDURES FOR DOMESTIC WATER SYSTEM BOOSTER PUMPS

- A. Adjust pumps to deliver total design flow.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or 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.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
 - B. Adjust flow-measuring devices installed in mains and branches to design water flows.
 1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
 - C. Verify final system conditions as follows:
 1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
 - D. Verify that memory stops have been set.
- 3.7 PROCEDURES FOR DOMESTIC HOT-WATER CIRCULATING INLINE PUMP
- A. Balance system with manual or automatic balancing valves by setting at design flow.
 1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
 - B. 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.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
 3. Mark final settings and verify that all memory stops have been set.
 4. Verify final system conditions as follows:
 - a. Re-measure and confirm that total flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.

- c. Mark final settings.

3.8 PROCEDURES FOR WATER HEATERS

- A. Measure and record entering- and leaving-water temperatures.
- B. Measure and record water flow.
- C. Measure and record pressure drop.
- D. Measure and Record relief valve(s) pressure setting.
- E. Capacity: Calculate in Btu/h (kW) of heating output.
- F. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

3.9 TOLERANCES

- A. Set plumbing system's flow rates within the following tolerances:
 - 1. Domestic Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm (0.63 L/s), within 10 percent.

3.10 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to plumbing systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.11 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.
 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Manufacturers' test data.
 3. Field test reports prepared by system and equipment installers.
 4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB specialist.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents, including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Notes to explain why certain final data in the body of reports vary from indicated values.
 14. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of distribution systems. Present each system with single-line diagram and include the following:
1. Flow rates.
 2. Pipe and valve sizes and locations.
 3. Balancing stations.
 4. Position of balancing devices.

- E. Water Heater Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Model number and unit size.
 - d. Manufacturer's serial number.
 - e. Output capacity in Btu/h (kW).
 - f. Number of stages.
 - g. Connected volts, phase, and hertz.
 - h. Rated amperage.
2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h (kW).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. High-temperature-limit setting in deg F (deg C).
 - e. Operating set point in deg F (deg C).
 - f. Voltage at each connection.
 - g. Amperage for each phase.

- F. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm (L/s).
 - g. Water-pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump speed.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig (kPa).
- b. Pump shutoff pressure in feet of head or psig (kPa).
- c. Actual impeller size in inches (mm).
- d. Full-open flow rate in gpm (L/s).
- e. Full-open pressure in feet of head or psig (kPa).
- f. Final discharge pressure in feet of head or psig (kPa).
- g. Final suction pressure in feet of head or psig (kPa).
- h. Final total pressure in feet of head or psig (kPa).
- i. Final water flow rate in gpm (L/s).
- j. Voltage at each connection.
- k. Amperage for each phase.

G. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.12 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION 220593

SECTION 220716 - PLUMBING EQUIPMENT INSULATION

PART 1 - 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.
2. Domestic water storage tanks.
3. Domestic water filter housings.

B. Related Sections:

1. Section 220719 "Plumbing Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material test reports

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

- 1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
- 2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.5 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 equipment Installer for equipment insulation application.
- C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Indoor Equipment Insulation Schedule" Article for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall 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 shall be qualified as acceptable in accordance with ASTM C795.

- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type II for sheet materials.
- G. Mineral-Fiber Blanket: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II, and ASTM C1290, Type II, with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Mineral-Fiber Board: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. Provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Pipe and Tank: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1393.
 - 1. Semirigid board material with factory-applied ASJ jacket.
 - 2. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more.
 - 3. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534/C534M or ASTM C1427, Type II, Grade 1 for sheet materials.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 - 2. Wet Flash Point: Below 0 deg F (minus 18 deg C)
 - 3. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 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: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
- C. 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 (0.66 metric perms) at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C)

2.4 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 150 to plus 250 deg F (Minus 101 to plus 121 deg C).
 - 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 (Minus 40 to plus 121 deg C).
 - 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 (Minus 40 to plus 121 deg C).
 - 3. Color: White.

2.5 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.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 4 oz./sq. yd. (114 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering equipment.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.
- B. Metal Jacket:
 1. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 2.5-mil- (0.063-mm-) 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.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches (75 mm).
 2. Thickness: 11.5 mils (0.29 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches (75 mm).
 2. Thickness: 6.5 mils (0.16 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
 2. Thickness: 3.7 mils (0.093 mm).
 3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 4. Elongation: 5 percent.
 5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

- A. Bands:
1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal.
 2. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.
- 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- (2.6-mm) 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- (2.6-mm-)] [0.135-inch- (3.5-mm-)] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) 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 (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: [Copper- or zinc-coated, low-carbon steel] [Aluminum] [Stainless steel], fully annealed, 0.106-inch- (2.6-mm-) 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 (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - 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 (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed; 0.106-inch- (2.6-mm-) 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- (0.41-mm-) thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) 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- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

2.10 CORNER ANGLES

- A. Aluminum Corner Angles: 0.040-inch (1.0-mm-) thick, minimum 1- by 1-inch (25- by 25-mm), aluminum in accordance with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- B. Stainless Steel Corner Angles: 0.024-inch (0.61-mm-) thick, minimum 1- by 1-inch (25- by 25-mm) stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). 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 between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- 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 equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of equipment, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches (50 mm) 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.
- L. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- O. 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. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

- A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.

- c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints and 16 inches (400 mm) o.c. in both directions.
 - d. Do not over-compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins, and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches (75 mm).
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
 2. Fabricate boxes from stainless steel, at least 0.040 inch (1.0 mm) thick.
 3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 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.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Indoor Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.8 INDOOR EQUIPMENT INSULATION SCHEDULE

- A. Insulate indoor and outdoor equipment that is not factory insulated.
- B. Domestic chilled-water (potable) pump insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
 - 2. Mineral-Fiber Board: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
- C. Domestic hot-water pump insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. m nominal density.
 - 2. Mineral-Fiber Board: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. mnominal density.
- D. Above Grade domestic chilled-water (potable) storage tank insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber Blanket: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
3. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
4. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
5. Polyolefin: 1 inch (25 mm) thick.

E. Domestic water filter-housing insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
2. Mineral-Fiber Board: 1 inch (25 mm thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
3. Mineral-Fiber Pipe and Tank: 1 inches (25 mm) thick.

3.9 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:
 1. Aluminum, Stucco Embossed: 0.016 inch (0.41 mm) thick.
- D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
 1. Aluminum, Stucco Embossed: 0.016 inch (0.41 mm) thick.
- E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 1. Stucco Embossed 0.032 inch (0.81 mm)] [0.040 inch (1.0 mm)] thick.

3.10 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. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:

1. Aluminum, Stucco Embossed: 0.024 inch (0.61 mm) thick.
- D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
 1. Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch (0.61 mm) thick.
- E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 1. Stucco Embossed 0.032 inch (0.81 mm)] [0.040 inch (1.0 mm) thick.

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. Supplies and drains for handicap-accessible lavatories and sinks.
- B. Related Sections:
 - 1. Section 220716 "Plumbing Equipment Insulation" for equipment insulation.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
- C. Samples: For each type of insulation and jacket indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material test reports.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.
- 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 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.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall 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 shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 1. Preformed Pipe Insulation: Type II, Class 1, without jacket.
 - 2. Preformed Pipe Insulation: Type II, Class 2, with factory-applied [ASJ] [ASJ-SSL] jacket.
 - 3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials.
- H. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.
 - 1. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
 - 2. 850 deg F (454 deg C).
 - 3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534/C534M or ASTM C1427, Type I, Grade 1, for tubular materials.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. 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 (minus 73 to plus 93 deg C).
- C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 - 2. Wet Flash Point: Below 0 deg F (minus 18 deg C).
 - 3. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- E. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
- F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 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: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
- C. 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 (0.66 metric perms) at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

2.4 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be 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 (Minus 50 to plus 80 deg C).

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 (Minus 40 to plus 121 deg C).
3. Color: Aluminum.

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 (Minus 40 to plus 121 deg C).
3. Color: White.

2.5 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.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.
 - 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.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 1. Width: 3 inches (75 mm).
 2. Thickness: 11.5 mils (0.29 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 1. Width: 3 inches (75 mm).
 2. Thickness: 6.5 mils (0.16 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. 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. Width: 2 inches (50 mm).
 2. Thickness: 6 mils (0.15 mm).

3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal.
2. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: [0.062-inch (1.6-mm) soft-annealed, stainless steel.

2.10 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Piping Enclosures:

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. Truebro; a brand of IPS Corporation.
 - b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
2. 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 PREPARATION

- A. 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range of between 140 and 300 deg F (60 and 149 deg C). 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 (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.2 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, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
- 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.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (100 mm) 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 more than 25 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) 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.

3.3 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 (50 mm) 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 (50 mm).
 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."

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, 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 made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation 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 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 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 as required. Installation shall conform 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 (50 mm) 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.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - 3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
 - 4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed 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 sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

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

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 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.

3.9 FIELD-APPLIED JACKET INSTALLATION

- #### A.
- Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) 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.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. 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 shall be 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.
- C. All insulation applications will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- 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.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch (13 mm) thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) thick.
 - c. Polyolefin: 1/2 inch (13 mm) thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - c. Polyolefin: 1 inch (25 mm) thick.
2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1-1/2 inch (38 mm) thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch (38 mm) thick.
 - c. Polyolefin: 1-1/2 inch (38 mm) thick.

C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Install Protective Shielding Piping Enclosures as specified above.

D. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drains Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch (13 mm) thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) thick.
 - c. Polyolefin: 1/2 inch (13 mm) thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. Aluminum, Smooth: 0.016 inch (0.41 mm) thick.

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. Rainwater retention piping, water treatment, pumping and storage.equipment.
 - 5. Plumbing pumps.
 - 6. 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. IgCC: International Green Construction Code.
- E. "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. 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 ASHRAE 202 and to resolve any issues with the CxA.

- B. 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. 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform commissioning process for plumbing systems in accordance with:
1. ASHRAE 202.

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, as detailed in ASHRAE 202. 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. Systems required to be commissioned:
1. Facility water-distribution piping, including the following:
 - a. Domestic and fire-suppression 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 and seismic restraints.
 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 and seismic restraints.
 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 and seismic restraints.
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. Heat tracing.
 - j. Vibration isolation and seismic restraints.
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. Emergency plumbing fixtures, supplies, drain connections, and controls.
 - h. 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 according 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.

3.6 CONSTRUCTION CHECKLIST EXAMPLES

A. General

1. Specific test procedures are to be developed by the CxA or Contractor.

END OF SECTION 220800

SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes water-distribution piping and related components outside the building for water service mains.
- B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

- A. PE: Polyethylene plastic.
- B. PP: Polypropylene plastic.
- C. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

A. Regulatory Requirements:

- 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
- 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
- 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. 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.

D. Comply with ASTM F645 for selection, design, and installation of thermoplastic water piping.

E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

- 1. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

1.8 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. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

C. Protect flanges, fittings, and specialties from moisture and dirt.

D. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than three days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of water-distribution service without written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Application" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

2.2 PE PIPE AND FITTINGS

- A. PE, ASTM Pipe: ASTM D2239, SDR No. 5.3, 7, or 9; with PE compound number required to give pressure rating not less than 160 psig (1100 kPa).
 - 1. Insert Fittings for PE Pipe: ASTM D2609, made of PA, PP, or PVC with serrated male insert ends matching inside of pipe. Include bands or crimp rings.
 - 2. Molded PE Fittings: ASTM D3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
- B. PE, AWWA Pipe: AWWA C906, DR No. 7.3, 9, or 9.3; with PE compound number required to give pressure rating not less than 160 psig (1100 kPa).
 - 1. PE, AWWA Fittings: AWWA C906, socket- or butt-fusion type, with DR number matching pipe and PE compound number required to give pressure rating not less than 160 psig (1100 kPa).

2.3 PVC PIPE AND FITTINGS

- A. PVC, Schedule 80 Pipe: ASTM D1785.

1. PVC, Schedule 80 Socket Fittings: ASTM D2467.

2.4 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.5 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers:

1. Standard: ASSE 1013 and AWWA C511.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.
4. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
- C. Do not use flanges or unions for underground piping.
- D. Underground water-service piping NPS 3/4 to NPS 3 (DN 20 to DN 80) shall be any of the following:
 1. PE, ASTM pipe; insert fittings for PE pipe; and clamped] [molded PE fittings; and heat-fusion] joints.
 2. PVC, Schedule 80 pipe; PVC, Schedule 80 socket fittings; and solvent-cemented joints.

3. Or other owner pre-approved alternates
- E. Underground water-service piping NPS 4 to NPS 8 (DN 100 to DN 200) shall be any of the following:
1. PE, AWWA pipe; PE, AWWA fittings; and heat-fusion joints.
 2. PVC, Schedule 80 pipe; PVC, Schedule 80 socket fittings; and solvent-cemented joints.
 3. NPS 4 and NPS 6 (DN 100 and DN 150) PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 fabricated or molded fittings; and gasketed joints.
 4. Or other owner pre-approved alternates

3.2 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main or tap water main according to requirements of water utility company and of size and in location indicated.
- B. Bury piping with depth of cover over top at least 24 inches (635 mm) and according to the following:
1. Under Driveways: With at least 36 inches (910 mm) cover over top.
 2. Under Railroad Tracks: With at least 48 inches (1220 mm) cover over top.
 3. In Loose Gravelly Soil and Rock: With at least 36 inches (910 mm) cover over top.
- C. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- D. Install underground piping with restrained joints at horizontal and vertical changes in direction.

3.3 JOINT CONSTRUCTION

- A. Make pipe joints according to the following:
1. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
 2. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D2774 or ASTM D3139 and pipe manufacturer's written instructions.

3.4 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

3.6 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
- C. Do not install bypass piping around backflow preventers.
- D. Support NPS 2-1/2 (DN 65) and larger backflow preventers, valves, and piping.

3.7 CONNECTIONS

- A. Connect water-distribution piping to water supply.
- B. Connect water-distribution piping to interior domestic water piping.

3.8 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

- C. Prepare reports of testing activities.

3.9 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Delete paragraph below if metallic water-service piping without electrically insulated fittings will be used.
- B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel.

3.10 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
 - c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. CPVC piping.
2. PEX tube and fittings.
3. PEX pipe and fittings
4. PVC pipe and fittings.
5. Polypropylene
6. Piping joining materials.
7. Transition fittings.
8. Dielectric fittings.

B. Related Requirements:

1. Section 221113 "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.2 ACTION SUBMITTALS

- #### A. Product Data: For transition fittings and dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

- #### A. System purging and disinfecting activities report.
- #### B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- #### A. Installer qualifications for PEX products: Installer shall have successfully completed the Uponor Piping Systems Training Course and is able to provide proof/verification. Course shall be conducted by the manufacturer or a manufacturer's representative.
1. Regulatory requirements and approvals: Ensure the piping distribution system complies with all applicable codes and regulations.
 2. Certifications: Provide letters of certification indicating: Installer uses skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed tradesperson.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- B. Storage and protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.
 - 1. Store PEX piping in cartons or under cover to avoid dirt or foreign material from entering the piping.
 - 2. Do not expose white PEX tubing to direct sunlight for more than one month or red or blue PEX tubing to direct sunlight for more than 6 months. If construction delays are encountered, cover the tubing to prevent exposure to direct sunlight.
 - 3. Store piping on a flat surface to prevent unwanted deformation.

1.6 WARRANTY

- A. Manufacturer's warranty: PEX-a manufacturer system warranty shall cover piping and fittings for a duration of 25 years from the date of installation. Piping system warranty shall apply to potable water distribution and water service systems constructed of pipe and fitting products sourced from the same manufacturer.

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.
- B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

2.2 CPVC PIPING

- A. CPVC Pipe: ASTM F441/F441M, with wall thickness as indicated in "Piping Applications" Article.
 - 1. CPVC Socket Fittings: ASTM F438 for Schedule 40.
- B. CPVC Piping System: ASTM D2846/D2846M, SDR 11, pipe and socket fittings.

2.3 PEX TUBE AND FITTINGS

- A. Tube Material: PEX plastic according to ASTM F876.
- B. Fittings: ASTM F1807, metal insert and copper crimp rings and ASTM F1960, cold expansion fittings and reinforcing rings.
- C. Push-Fit Fittings: ASSE 1061, push-fit fittings.
- D. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F876; with plastic or corrosion-resistant-metal valve for each outlet.

2.4 PEX WATER PIPING AND FITTINGS

- A. Performance requirements:
 - 1. PEX-a piping and fittings shall meet the following pressure and temperature ratings per ASTM F876:
 - a. 200 degrees F (93 degrees C) at 80 psi (551 kPa).
 - b. 180 degrees F (82 degrees C) at 100 psi (689 kPa).
 - c. 73.4 degrees F (23 degrees C) at 160 psi (1,102 kPa).
 - 2. PEX-a piping and fittings shall be tested for compliance by an independent third-party agency.
 - 3. Minimum bend radius (cold bending): Six times the outside diameter.
 - 4. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.
 - a. UL Design No. L557 1 hour wood frame floor/ceiling assemblies.
 - b. UL Design No. K913 2 hour concrete floor/ceiling assemblies.
 - c. UL Design No. U372 1 hour wood stud/gypsum wallboard wall assemblies.
 - d. UL Design No. V444 1 hour steel stud/gypsum wallboard wall assemblies.
 - 5. PEX-a piping shall be tested to comply with the ASTM F2023 requirement for minimum chlorine resistance at the end use condition of 100% of the time at 140°F (60°C) at 80 psi (0.55 MPa) gauge pressure.
 - a. PEX-a piping and tubing material designation codes shall be PEX 5106 or PEX 5306.
- B. Piping:
 - 1. Pipe

- a. PEX-a (Engel-method crosslinked polyethylene), ASTM F876 and F877 (CAN/CSA-B137.5), SDR 9, CTS, 1/2 inch (16mm) through 3 inch (75mm) nominal pipe size.
2. Pre-sleeved piping
 - a. High-density polyethylene (HDPE) corrugated sleeved PEX-a (Engel-method crosslinked polyethylene), ASTM F876 and F877 (CAN/CSA-B137.5), SDR 9, CTS, 1/2 inch (16mm) and 3/4 inch (19 mm) nominal pipe size.
3. Pre-insulated piping
 - a. Factory fabricated and assembled Uponor AquaPEX PEX-a piping with a closed-cell polyethylene foam insulation, 1/2 inch (16mm) through 2 inch (51mm) nominal pipe size.
4. Insulation shall not be exposed to groundwater

C. Fittings:

1. Third-party certified to NSF 14 and ASTM F1960 cold-expansion with PEX reinforcing ring and shall comply with ASTM F876 and ASTM F877, 1/2 inch through 3 inch nominal pipe size fittings manufactured from the following material types:
2. Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked "F1960".

2.5 PVC PIPE AND FITTINGS

- A. PVC Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.
- B. PVC Socket Fittings: ASTM D2466 for Schedule 40

2.6 POLYPROPYLENE PIPE AND FITTINGS

- A. Pipe shall be manufactured from a PP-R resin (Fusiolen) meeting the short-term properties and long-term strength requirements of ASTM F 2389. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in an extrusion process. Domestic hot water shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F 2389. All pipe shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.
- B. Fittings shall be manufactured from a PP-R resin (Fusiolen) meeting the short-term properties and long-term strength requirements of ASTM F 2389. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same

specification from the same raw material. All fittings shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.

- C. Valves shall be manufactured in accordance with the manufacturer's specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11. The valves shall contain no rework or recycled thermoplastic materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.
- D. Warranty
 - 1. Manufacturer shall warrant pipe and fittings for 10 years to be free of defects in materials or manufacturing.
 - 2. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 3. Warranty shall be in effect only upon submission by the contractor to the manufacturer of valid pressure/leak test documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

2.7 PIPING JOINING MATERIALS

- A. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493.
- B. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.
- C. Fusion welding of polypropylene joints
 - 1. Install fittings and joints using socket-fusion, electrofusion, or butt-fusion as applicable for the fitting type. All fusion-weld joints shall be made in accordance with the pipe and fitting manufacturer's specifications and product standards.
 - 2. Fusion-weld tooling, welding machines, and electrofusion devices shall be as specified by the pipe and fittings manufacturer.
 - 3. Prior to joining, the pipe and fittings shall be prepared in accordance with ASTM F 2389 and the manufacturer's specifications.
 - 4. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

2.8 TRANSITION FITTINGS

- 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. Plastic-to-Metal Transition Fittings:
 - 1. Description:
 - a. CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
 - b. One end with threaded brass insert and one solvent-cement-socket end.
- D. Plastic-to-Metal Transition Unions:
 - 1. Description:
 - a. CPVC or PVC four-part union.
 - b. Brass or stainless steel threaded end.
 - c. Solvent-cement-joint or threaded plastic end.
 - d. Rubber O-ring.
 - e. Union nut.
- E. PEX-to-metal transition fittings:
 - 1. Manufacturers: Provide fittings from the same manufacturer of the piping.
 - 2. Third-party certified to NSF 14 and ASTM F1960 cold-expansion with PEX reinforcing ring and shall comply with ASTM F876 and ASTM F877, 1/2 inch through 3 inch nominal pipe size fittings manufactured from the following material types:
 - 3. PEX-a to thread transition: One-piece Lead free (LF) brass fitting with male or female threaded adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
 - 4. PEX-a to copper sweat transition: One-piece lead free (LF) brass fitting with sweat adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
 - 5. PEX-a to copper press transition: One-piece lead free (LF) brass fitting with one ASME B16.51 copper press end and one ASTM F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
 - 6. PEX-a to flange transition: Two-piece fitting with one steel flange conforming to ASME B 16.5 and one lead free (LF) brass adapter conforming to ASTM F1960.
 - 7. PEX-a to groove transition: One-piece lead free (LF) brass fitting with one CSA B242-05 groove end in either iron pipe size (IPS) or copper tube size (CTS) and one ASTM F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
 - 8. PEX-a to water meter transition: Two-piece fitting with one NPSM union thread and one ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
- F. PEX-to-thermoplastic transition fittings:

1. PEX-a to CPVC transition: Thermoplastic fitting with one spigot or socket end and one ASTM F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.

2.9 VALVES

- A. PEX-to-PEX, lead-free (LF) brass ball valves (1/2 inch (13 mm) through 2 inch (50 mm) nominal pipe size)
 1. Manufacturers: Provide ball valve(s) from the same manufacturer as the piping system.
 2. Full-port ball valve: two-piece, ASTM F1960 cold-expansion ends, with PEX-a reinforcing cold-expansion ring.
 3. LF brass valve with a positive stop shoulder.
 4. In compliance with 250 CWP, ANSI/NSF 359, ANSI/NSF 372, ANSI/NSF 14/61, cNSF-us-pw_G lead free 0.25% lead maximum, ASTM F1960, ASTM F877 (CAN/CSA B137.5).
 5. Provide stem extension kits for insulated piping.
- B. PEX-to-NPSM, lead-free (LF) full-port brass water meter service valve
 1. 3/4 inch PEX x 1 inch NPSM straight and elbow
 2. 1 inch PEX x 1-1/4 inch NPSM straight and elbow
 3. Metal and polypropylene NPSM union nut
 4. In compliance with 250 CWP, ANSI/NSF 359, ANSI/NSF 14/61, cNSF-us-pw_G lead free 0.25% lead maximum, ASTM F1960, ASTM F877 (CAN/CSA B137.5).

2.10 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Standard: ASSE 1079.
 2. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 3. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Nipples:
 1. Standard: IAPMO PS 66.
 2. Electroplated steel nipple complying with ASTM F1545.
 3. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 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. Under-building-slab, domestic water, building-service piping, NPS 8 (DN 200) and smaller, shall be the following:
 - 1. PVC, Schedule 40; socket fittings; and solvent-cemented joints.
 - 2. Or other owner pre-approved alternates
- D. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
 - 1. CPVC, Schedule 40; socket fittings; and solvent-cemented joints.
 - 2. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. NPS 1-1/2 (DN 40) and NPS 2 (DN 50) CPVC pipe with CPVC socket fittings may be used instead of tubing.
 - 3. Polypropylene (PP-R) piping in SDR 7.4, 11, or 17.6 based on the required minimum pressure rating and use temperature, in accordance with manufacturer's instructions and ASTM F2389.
 - 4. PEX tube, NPS 1 (DN 25) and smaller.
 - a. Fittings for PEX tube:
 - 1) ASTM F1807, metal insert and copper crimp rings.
 - 2) ASTM F1960, cold expansion fittings and reinforcing rings.
 - 3) ASSE 1061, push-fit fittings.
 - 5. PEX Piping:
 - a. 3 inch (75mm) and smaller:
 - 1) PEX-a piping with engineered polymer (EP) or lead-free brass ASTM F1960 cold-expansion fittings.
 - b. 2 inch (51mm) and smaller:
 - 1) Pre-Insulated PEX-a piping with engineered polymer (EP) or lead-free brass ASTM F1960 cold-expansion fittings.
 - 6. PVC, Schedule 40; socket fittings; and solvent-cemented joints.

7. Or other owner pre-approved alternates
- E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
 1. CPVC, Schedule 40; socket fittings; and solvent-cemented joints.
 2. PVC, Schedule 40; socket fittings; and solvent-cemented joints.
 3. Polypropylene (PP-R) piping in SDR 7.4, 11, or 17.6 based on the required minimum pressure rating and use temperature, in accordance with manufacturer's instructions and ASTM F2389.
 4. Or other owner pre-approved alternates
- F. Aboveground domestic water piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:
 1. Polypropylene (PP-R) piping in SDR 7.4, 11, or 17.6 based on the required minimum pressure rating and use temperature, in accordance with manufacturer's instructions and ASTM F2389.
 2. Or other owner pre-approved alternates

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 water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."
- C. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- D. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

- F. 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.
- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- H. Install piping to permit valve servicing.
- I. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- J. Install piping free of sags and bends.
- K. Install fittings for changes in direction and branch connections.
- L. Install PEX tubing with loop at each change of direction of more than 90 degrees.
- M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- N. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gauges in Section 220519 "Meters and Gages for Plumbing Piping."
- O. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."
- P. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors.
- R. Install sleeve seals for piping penetrations of concrete walls and slabs.
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
 - 2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
 - 3. PVC Piping: Join according to ASTM D2855.
- E. Joints for PEX Tubing, ASTM: Join according to ASTM F1807 for metal insert and copper crimp ring fittings and ASTM F1960 for cold expansion fittings and reinforcing rings.
- F. Joints for PEX Tubing, ASSE: Join according to ASSE 1061 for push-fit fittings.
- G. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.
- H. PEX-a connections:
 - 1. Install per manufacturer's recommendations.
 - 2. Use manufacturer-recommended cold-expansion ProPEX tool for ASTM F1960 connections.

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 (DN 40) and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

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 (DN 50) and Smaller: Use dielectric couplings or nipples.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges].

3.7 INSTALLATION OF PEX PIPING

- A. Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings, including the following.
- B. Install PEX piping system in compliance with the manufacturer's installation guide.
- C. PEX shall not be installed in areas within five feet of a UV light source, such as LED and fluorescent light fixtures or other UV generating devices.
- D. White PEX shall not be installed outdoors where it is exposed to direct sunlight light for more than one month; red or blue PEX shall not be installed outdoors where it is exposed to direct sunlight for more than six months.
- E. PEX piping shall be installed per ASTM E84 requirements for plenum applications.
- F. Install PEX-a Pipe Support and provide all required hangers and supporting strapping as required by manufacturer to provide a code compliant installation.
- G. Install PEX piping in straight runs free of sags and kinks and provide bend supports at all 1/2 inch and 3/4 inch drops.
- H. All PEX piping penetrations through wall plates shall be protected or shielded as required to prevent damage to piping.
- I. PEX tubing passing through metal studs shall use grommets or sleeves at the penetration.
- J. Install PEX piping from the multiport tee or manifold to each fixture as a home run.
- K. Install PEX-a Pipe Support, fixed anchor points and hangers in compliance with Uponor Plumbing Design Assistance Manual (PDAM) to minimize expansion and contraction.
- L. Install PEX piping at each fixture with out of the wall support bracket to secure piping and prevent excess movement when water stops or shut valves are operated.
- M. Install all PEX manifolds centered in access panels to permit servicing.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

- B. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- C. Install vinyl-coated hangers for CPVC and PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install vinyl-coated hangers for PEX tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support vertical runs of PEX tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- F. Support horizontal piping within 12 inches (300 mm) of each fitting.
- G. Support vertical runs of CPVC and PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.9 PEX-a piping hangers and supports

- A. Horizontal PEX-a piping: Install supports suitable for PEX-a piping in compliance with local codes and the Uponor Piping Systems Installation Guide, current edition.
 - 1. Note: Per ICC PMG-1006, the above maximum hanger spacing requirements may be extended with the use of a continuous support channel such as Uponor PEX-a Pipe Support.
- B. Horizontal PEX-a piping with PEX-a Pipe Support: Install supports for PEX-a piping with horizontal support channel in accordance with manufacturer's recommendations and the following maximum spacing:
 - 1. 3 inch nominal and smaller: Maximum span, 8 feet (2.4 m).
 - 2. Support 1-1/2 inch and smaller fittings within 12 inches (0.3 m).
 - 3. Install clamps and fixed points per the Uponor Piping Systems Installation Guide, current edition.
- C. Vertical PEX-a piping: Install supports suitable for PEX-a piping in compliance with local codes and the Uponor Piping Systems Installation Guide, current edition:
 - 1. Support vertical in-wall piping every 5 feet (1.5 m).
 - 2. Support riser piping at the base of each floor and every 5 feet (1.5 m) vertically.
 - a. Refer to the Uponor Piping Systems Installation Guide, current edition, for additional requirements.

3.10 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 (DN 65) and larger.

3.11 IDENTIFICATION

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

3.12 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.

3.13 FIELD QUALITY CONTROL

A. Perform the following 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 roughing in 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 (345 kPa) 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.

3.14 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 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) 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 (200 mg/L) 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.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers for domestic water piping.
7. Hose bibbs.
8. Wall hydrants.
9. Water-hammer arresters.
10. Trap-seal primer device.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.
1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Test and inspection reports.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and 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.

2.2 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Standard: ASSE 1001.
 - 2. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
 - 3. Body: Bronze.
 - 4. Inlet and Outlet Connections: Threaded.
 - 5. Finish: Rough bronze.
- B. Hose-Connection Vacuum Breakers:
 - 1. Standard: ASSE 1011.
 - 2. Body: Bronze, nonremovable, with manual drain.
 - 3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 - 4. Finish: Chrome or nickel plated.

2.3 BACKFLOW PREVENTERS

- A. Intermediate Atmospheric-Vent Backflow Preventers:
 - 1. Standard: ASSE 1012.
 - 2. Operation: Continuous-pressure applications.
 - 3. Body: Bronze.
 - 4. End Connections: Union, solder joint.
 - 5. Finish: Rough bronze.
- B. Reduced-Pressure-Principle Backflow Preventers:
 - 1. Standard: ASSE 1013.
 - 2. Operation: Continuous-pressure applications.
 - 3. Pressure Loss: 14 psig maximum, through middle third of flow range.

4. Body: Lead Free Bronze for NPS 2 (DN 50) and smaller; ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) 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. Double-Check, Backflow-Prevention Assemblies:

1. Standard: ASSE 1015.
2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Pressure Loss: 6 psig maximum, through middle third of flow range.
4. Body: Lead Free Bronze for NPS 2 (DN 50) and smaller; ductile or cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Standard: ASSE 1003.
2. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
3. Body: Bronze for NPS 2 (DN 50) 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 (DN 65 and DN 80).
4. Valves for Booster Heater Water Supply: Include integral bypass.
5. End Connections: Threaded or solder for NPS 2 (DN 50) and smaller; flanged or solder for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

2.5 BALANCING VALVES

A. Memory-Stop Balancing Valves:

1. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
2. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
3. Size: NPS 2 (DN 50) or smaller.
4. Body: Copper alloy.
5. Port: Standard or full port.
6. Ball: Chrome-plated brass or stainless steel.
7. Seats and Seals: Replaceable.
8. End Connections: Solder joint or threaded.
9. Handle: Vinyl-covered steel with memory-setting device.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Standard: ASSE 1070.
2. Pressure Rating: 125 psig (860 kPa).
3. Type: Thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded inlets and outlet.
6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Tempered-Water Setting: 110 deg F.

B. Primary, Thermostatic, Water Mixing Valves:

1. Standard: ASSE 1017.
2. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
3. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded or union inlets and outlet.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Tempered-Water Setting: 110 deg F.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.

2. Body: Bronze for NPS 2 (DN 50) 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 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 (DN 50) and Smaller: 0.020 inch (0.51 mm).
 - b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch (1.14 mm).
 - c. Strainers NPS 5 (DN 125) and Larger: 0.10 inch (2.54 mm).
6. Drain: Pipe plug.

2.8 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 (DN 15 or DN 20) threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig (860 kPa).
7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish: Rough bronze, or chrome or nickel plated.
9. Include operating key with each operating-key hose bibb.

2.9 WALL HYDRANTS

A. Moderate-Climate Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig (860 kPa).
3. Operation: Loose key.
4. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
5. Outlet, Concealed:
 - a. With integral vacuum breaker or nonremovable 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.
6. Box: Deep, flush mounted with cover.

7. Box and Cover Finish: Polished nickel bronze.

2.10 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Piston.
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.11 TRAP-SEAL PRIMER DEVICE

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

1. Standard: ASSE 1018.
2. Pressure Rating: 125 psig (860 kPa) minimum.
3. Body: Bronze.
4. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.12 TRAP SEAL PROTECTION DEVICES

A. Barrier Type Trap Seal Protection Devices:

1. Basis-of-Design Product: Subject to acceptance by the local jurisdiction, provide SureSeal Manufacturing; Inline Floor Drain Trap Sealer, or a comparable product with IAPMO approval from another manufacturer.
2. Standard: ASSE 1072-2007.
3. Body: ASB Plastic
4. Diaphragm & Sealing Gasket: Neoprene Rubber
5. Size: 2 inch (50 mm), 3 inch (75 mm), 3-1/2 inch (89 mm), or 4 inch (100 mm).
6. Gravity Drain Outlet Connection: Compression fit sealing gasket 80 durometer.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- #### A. Backflow Preventers:
- Install 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. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gauges on inlet and outlet.
- C. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.
- D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- E. Y-Pattern Strainers: For water, install on supply side of each water pressure-reducing valve and pump.
- F. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.
- G. Supply-Type, Trap-Seal Primer Device: Install 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.
- H. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.
- I. Install supply-type, trap-seal primer valves or Barrier Type Trap Seal Protection Devices on all traps subject to evaporation (floor drains, floor sinks, etc.). 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.
- 3.2 PIPING CONNECTIONS
- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.3 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.
- D. Adjust each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly, and double-check, detector-assembly backflow preventer in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Test each pressure vacuum breaker, 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.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 221119

SECTION 221123 - INLINE, DOMESTIC-WATER CIRCULATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line, wet rotor circulators.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: One year from date of Substantial Completion.
 2. Warranty shall include a 1 year labor warranty.

PART 2 - PRODUCTS

2.1 IN-LINE, WET ROTOR CIRCULATORS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:

1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Corporation.
3. Grundfos Pumps Corp.
4. TACO Incorporated.
5. Wilo

B. Pump Construction:

1. Pump Body: Lead free bronze
2. Impeller: Noryl
3. Shaft: Ceramic
4. Bearings: Double-Sintered Carbon
5. Motor: Single speed, unless otherwise indicated.

C. Capacities and Characteristics: As indicated on the plans.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors appropriate for the proposed service.

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.

2.3 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F (18 to 93 deg C).
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Settings: Start pump at 110 deg F and stop pump at 120 deg F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Operation of Pump: On or off.
3. Transformer: Provide if required.
4. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install pumps with shaft horizontal unless otherwise indicated.
- C. Install continuous-thread hanger rods of size required to support pump weight (if weight is such that support by connecting piping is not adequate). Support per manufacturer's instructions.
- D. Install thermostats in hot-water return piping.
- E. Install timers on wall adjacent to water heater.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
- D. Connect thermostats and timers to pumps that they control.

3.3 ADJUSTING

- A. Install balancing valves at the end of each hot water recirculation line and other locations as required to balance the recirculation system flow.
 - 1. Install balancing valves in locations where they can easily be adjusted.
- B. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- C. Adjust initial temperature set points.
- D. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123

SECTION 221123.13 - DOMESTIC-WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes Variable Speed Packaged Pumping Systems for domestic water piping systems.

1.3 SUBMITTALS

- A. Product Data: For each packaged booster pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
- B. Shop Drawings: For packaged booster pumps and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - 4. Wiring Diagrams: Detail power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that packaged booster pumps, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Operation and Maintenance Data: For each packaged booster pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. All pumps must have a pump efficiency index (PEI) less than or equal to one where required per DOE regulations.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged booster pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. 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.
- D. ASME Compliance: Comply with ASME B31.9 for piping.
- E. Packaged booster pumps shall be listed and labeled as pumping systems by testing agency acceptable to authorities having jurisdiction.
- F. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.
- G. C.The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.
- H. D.The complete packaged pumping system shall be NSF61 Annex G Listed for drinking water and low lead requirements.

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 rigging instructions for handling.

1.6 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.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

PART 2 - PRODUCTS

2.1 VARIABLE-SPEED, MULTIPLEX BOOSTER PUMPS

- A. The pumps shall be of the in-line vertical multi-stage design.
- B. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.
- C. Small Vertical In-Line Multi-Stage Pumps (Nominal flow from 3 to 125 gallons per minute) shall have the following features:
 - 1. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.
 - 2. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.
 - 3. Pump Construction.
 - a. Suction/discharge base, pump head, motor stool: cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel
 - b. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
 - c. Shaft 316 or 431 Stainless Steel

- d. Impeller wear rings: 304 Stainless Steel
- e. Shaft journals and chamber bearings: Silicon Carbide
- f. O-rings: EPDM

Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

- 4. The shaft seal shall be a balanced o-ring cartridge type with the following features:
 - a. Collar, Drivers, Spring: 316 Stainless Steel
 - b. Shaft Sleeve, Gland Plate: 316 Stainless Steel
 - c. Stationary Ring: Silicon Carbide
 - d. Rotating Ring: Silicon Carbide
 - e. O-rings: EPDM

The Silicon Carbide shall be imbedded with graphite.

- 5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

D. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 500 gallons per minute) shall have the following features:

- 1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.
- 2. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.
- 3. Pump Construction.
 - a. Suction/discharge base, pump head Ductile Iron (ASTM 65-45-12)
 - b. Shaft couplings, flange rings: Ductile Iron (ASTM 65-45-12)
 - c. Shaft 431 Stainless Steel
 - d. Motor Stool Cast Iron (ASTM Class 30)
 - e. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
 - f. Impeller wear rings: 304 Stainless Steel
 - g. Intermediate Bearing Journals: Tungsten Carbide
 - h. Intermediate Chamber Bearings: Leadless Tin Bronze
 - i. Chamber Bushings: Graphite Filled PTFE
 - j. O-rings: EPDM
- 4. The shaft seal shall be a single balanced metal bellows cartridge with the following construction:

- a. Bellows: 904L Stainless Steel
 - b. Shaft Sleeve, Gland Plate, Drive Collar: 316 Stainless Steel
 - c. Stationary Ring: Carbon
 - d. Rotating Ring: Tungsten Carbide
 - e. O-rings: EPDM
5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

2.2 INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

- A. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.
- B. The VFD shall be of the PWM (Pulse Width Modulation) design using current IGBT (Insulated Gate Bipolar Transistor) technology.
- C. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.
- D. The VFD shall utilize an energy optimization algorithm to minimize energy consumption. The output voltage shall be adjusted in response to the load, independent of speed.
- E. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.
- F. An integral RFI filter shall be standard in the VFD.
- G. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.
- H. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.
- I. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

- J. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:
 - 1. Speed Reference Signal: 0-10 VDC, 4-20mA
 - 2. Digital remote on/off
 - 3. Fault Signal Relay (NC or NO)
 - 4. Fieldbus communication port (RS485)
- K. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.
- L. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.
- M. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

2.3 PUMP SYSTEM CONTROLLER

- A. The pump system controller shall be a standard product developed and supported by the pump manufacturer.
- B. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2" x 4-5/8" for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.
- C. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.
- D. The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.
- E. The controller shall have built in data logging capability. Logged values shall be graphically displayed on the controller and able to be exported to computer via standard connection. A minimum of 3600 samples per logged value with the following parameters available for logging:
 - 1. Estimated flow-rate
 - 2. Speed of pumps
 - 3. Inlet pressure
 - 4. Discharge pressure
 - 5. Power consumption
 - 6. Controlling parameter (process value)

- F. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):
1. Current value of the control parameter, (typically discharge pressure)
 2. Most recent existing alarm (if any)
 3. System status with current operating mode
 4. Status of each pump with current operating mode and rotational speed as a percentage (%)
 5. Estimated flow-rate, (not requiring flow meter connection)
- G. The controller shall have as a minimum the following hardware inputs and outputs:
1. Three analog inputs (4-20mA or 0-10VDC)
 2. Three digital inputs
 3. Two digital outputs
 4. Ethernet connection
 5. Field Service connection to PC for advanced programming and data logging
- H. Pump system programming (field adjustable) shall include as a minimum the following:
1. Water shortage protection (analog or digital)
 2. Transducer Settings (Suction and Discharge Analog supply/range)
 3. PI Controller (Proportional gain and Integral time) settings
 4. High system pressure indication and shut-down
 5. Low system pressure indication and shut-down
 6. Low suction pressure/level shutdown (via digital contact)
 7. Low suction pressure/level warning (via analog signal)
 8. Low suction pressure/level shutdown (via analog signal)
 9. Flow meter settings (if used, analog signal)
- I. The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).
- J. The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).
- K. The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

- L. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.
- M. The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.
- N. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:
 - 1. High System Pressure
 - 2. Low system pressure
 - 3. Low suction pressure (warning and alarm)
 - 4. Individual pump failure
 - 5. VFD trip/failure
 - 6. Loss of sensor signal (4-20 mA)
 - 7. Loss of remote set-point signal (4-20mA)
 - 8. System power loss
- O. The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

Control panel options shall include, but not be limited to:

 - 1. Pump Run Lights
 - 2. System Fault Light
 - 3. Audible Alarm (80 db[A])
 - 4. Surge Arrestor
 - 5. Emergency/Normal Operation Switches
 - 6. Service Disconnect Switches
 - 7. Qty (9) Configurable Digital Outputs available for monitoring
- P. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).
- Q. The controller shall have a pump “Test Run” feature such that pumps are switched on during periods of inactivity (system is switched to the “off” position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).
- R. The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

- S. The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).
- T. The controller shall be capable of displaying instantaneous specific energy use (kw/gpm), (optional flow meter must be connected).
- U. The actual pump performance curves (5th order polynomial) shall be loaded (software) into the pump system controller or be able to input manually into controller based on three points on pump curve of pumps controlled.
- V. The controller shall be capable of displaying an estimated flow-rate on the default status screen.
- W. The controller shall have the ability to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates without the requirement of a flow meter.
- X. The controller shall have the ability to communicate in BACnet, via optional communication expansion card installed inside controller.
- Y. The controller shall have a built in Ethernet connection allowing controller to connected to network and access of controller via web browser and internet anywhere around the world where internet communication is available.
- Z. The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

2.4 SEQUENCE OF OPERATION

- A. The system controller shall operate equal capacity variable speed pumps to maintain a constant discharge pressure (system set-point). The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer on the discharge manifold, indicating the actual system pressure. As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system pressure is equal to the system set-point all pumps in operation shall reach equal operating speeds. As flow demand decreases the pump speed shall be reduced while system set-point pressure is maintained. When all pumps in operation are running at low speed the system controller shall switch off pumps when fewer pumps are able to maintain system demand.
- B. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.
- C. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the

capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

- D. The system controller shall be able to control a pressure maintenance pump, (jockey pump), in the system. The set point of the pressure maintenance pump shall be able to be any value above or below the pump system's set point. The pressure maintenance pump shall be able to be staged on as back-up pump when capacity of pump system is exceeded.

2.5 LOW FLOW STOP FUNCTION

- A. The system controller shall be capable of stopping pumps during periods of low-flow or zero-flow without wasting water or adding unwanted heat to the liquid. Temperature based no flow shut-down methods that have the potential to waste water and add unwanted temperature rise to the pumping fluid are not acceptable.
- B. Standard Low Flow Stop and Energy Saving Mode
 - 1. If a low or no flow shut-down is required (periods of low or zero demand) a bladder type diaphragm tank shall be installed with a pre-charge pressure of 70% of system set-point. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When only one pump is in operation the system controller shall be capable of detecting low flow (less than 10% of pump nominal flow) without the use of additional flow sensing devices. When a low flow is detected, the system controller shall increase pump speed until the discharge pressure reaches the stop pressure (system set-point plus 50% of programmed on/off band). The pump shall remain off until the discharge pressure reaches the start pressure (system set-point minus 50% of programmed on/off band). Upon low flow shut-down a pump shall be restarted in one of the following two ways:
 - a. Low Flow Restart: If the drop in pressure is slow when the start pressure is reached (indicating the flow is still low), the pump shall start and the speed shall again be increased until the stop pressure is reached and the pump shall again be switched off.
 - b. Normal Flow Restart: If the drop in pressure is fast (indicating the flow is greater than 10% of pump nominal flow) the pump shall start and the speed shall be increased until the system pressure reaches the system set-point.

It shall be possible to change from the standard low flow stop to the optional low flow stop (and vice-versa) via the user interface.

2.6 SYSTEM CONSTRUCTION

- A. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting

pipng protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation can not exist in manifold during operation to prevent bacteria growth inside manifold.

- B. The suction and discharge manifolds shall be constructed of 316 stainless steel. Manifold connection sizes shall be as follows:
 - 1. 3 inch and smaller: Male NPT threaded
 - 2. 4 inch through 8 inch: ANSI Class 150 rotating flanges
 - 3. 10 inch and larger: ANSI Class 150 flanges
- C. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.
- D. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.
- E. For systems that require a diaphragm tank, a connection of no smaller than 3/4" shall be provided on the discharge manifold.
- F. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.
- G. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2 1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.
- H. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.
- I. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

- J. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways:
1. On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
 2. On a 304 stainless steel fabricated skid, separate from the main system skid
 3. On its own base (floor mounted with plinth).

2.7 Capacity and Characteristics: Per the equipment schedules on the plans.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex-Pression, Ltd.
4. Flex-Weld, Inc.
5. Hyspan Precision Products, Inc.
6. Mercer Rubber.
7. Metraflex, Inc.
8. Proco Products, Inc.
9. Tozen America Corporation.
10. Unaflex Inc.

- B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include 175-psig (1200-kPa) minimum working-pressure rating and ends according to the following:

1. NPS 2 (DN 50) and Smaller: Threaded. Provide flanged ends if pump has flanged connections.
2. NPS 2-1/2 (DN 65) and Larger: Flanged.

2.9 BUILDING-AUTOMATION-SYSTEM INTERFACE

- A. Provide auxiliary contacts in pump controllers for interface to BACnet building automation system. Include the following:

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

2.10 TESTING

- A. The entire pump station shall be factory tested for functionality. Functionality testing shall include the following parameters: Dry Run Protection, Minimum Pressure and Maximum Pressure alarms (where applicable), Setpoint Operation, and Motor Rotation.
- B. The system shall undergo a factory hydrostatic test at the end of the production cycle. The system shall be filled with water and pressurized to 1.5 times the nameplate maximum pressure. Systems with 150# flange connections shall be tested at 350 psig, and systems with 300# flange connections shall be tested at 450 psig. The pressure shall be maintained for a minimum of 15 minutes with no leakage (slight leakage around pump(s) mechanical seal is acceptable) prior to shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for packaged booster pumps to verify actual locations of connections before booster pump installation.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for packaged booster pumps. Refer to Division 22 Section "Common Work Results for Plumbing."
 - 1. 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 base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
 - 4. Install anchor bolts to elevation required for proper attachment to supported equipment.
- B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 BOOSTER PUMP INSTALLATION

- A. Install packaged booster pumps level on concrete bases with access for periodic maintenance including removal of pumps, motors, impellers, couplings, and accessories.
 - 1. Do not dismantle packaged booster pumps or remove individual components.

- B. Support connected domestic water piping so weight of piping is not supported by packaged booster pumps.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect domestic water piping to packaged booster pumps. Install suction and discharge pipe equal to or greater than size of unit suction and discharge piping.
 - 1. Install flexible connectors on piping connections to unit suction and discharge piping. Install flexible connectors same size as piping.
 - 2. Install shutoff valves on piping connections to each booster pump suction and discharge piping. Install ball, butterfly, or gate valves same size as suction and discharge piping. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
 - 3. Install union or flanged connections on pump suction and discharge piping at connection to domestic water piping.
 - 4. Install piping adjacent to packaged booster pumps to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform the following startup service:
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers if any.
 - 4. Verify that pump controls are correct for required application.
- B. Perform the following startup checks for each pump of packaged booster pump unit before starting:
 - 1. Verify bearing lubrication.
 - 2. Prime pumps by opening suction valves and closing discharge valves, and prepare pumps for operation.
 - 3. Start motors.
 - 4. Open discharge valves slowly.
 - 5. Adjust settings.

- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting packaged booster pumps to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.6 LABELING AND IDENTIFICATION

- A. Install identifying equipment markers and equipment signs on booster pumps. Labeling and identification materials are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged booster pumps. Refer to Division 01 Section "Demonstration and Training"

END OF SECTION 221123.13

SECTION 221313 - FACILITY SANITARY SEWERS

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. ABS pipe and fittings.
 - 2. PVC pipe and fittings.
 - 3. HDPE pipe and fittings.
 - 4. Nonpressure-type transition couplings.
 - 5. Pressure-type pipe couplings.
 - 6. Expansion joints and deflection fittings.
 - 7. Backwater valves.
 - 8. Cleanouts.
 - 9. Manholes.
 - 10. Concrete.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Pipe and fittings.
 - 2. Non-pressure and pressure couplings
 - 3. Expansion joints and deflection fittings.
 - 4. Backwater valves.
 - 5. Cleanouts.
- B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:

1. Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
2. Show system piping in profile. Draw profiles to horizontal scale of not less than 1 inch equals 50 feet (1:500) and to vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

B. Product Certificates: For each type of pipe and fitting.

C. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

2.1 ABS PIPE AND FITTINGS

A. ABS Sewer Pipe and Fittings: ASTM D2661, with bell-and-spigot ends for gasketed joints.

1. NPS 3 to NPS 6 (DN 80 to DN 150): SDR 35.
2. NPS 8 to NPS 12 (DN 200 to DN 300): SDR 42.

B. Gaskets: ASTM F477, elastomeric seals.

2.2 PVC PIPE AND FITTINGS

A. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D 3034, SDR-26, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

2.3 High Density Polyethylene Pipe (HDPE) and fittings

- A. Shall meet the requirements of ASTM F714 Polyethylene (PE) Plastic Pipe (SDR-PR) based on outside diameter, ASTM 01248, ASTM 03350. All HDPE pipe shall be marked with a green stripe to signify its use for sanitary sewer utilities. Only solid wall HDPE pipe in accordance with ASTM F714 shall be accepted. HDPE profile wall pipe and fittings will not be accepted.
- B. Pipe shall be manufactured from high density high molecular weight polyethylene resin and shall conform to ASTM 01248. Minimum cell classification shall be 345434C as referenced in ASTM 03350-84.
- C. Pipe supplied under this specification shall have a nominal IPS (Iron Pipe Size) OD. The SDR (Standard Dimensional Ratio) of the pipe shall be SDR-11, 160 PSI or SDR-17, 100 PSI.
- D. Joints: Pipe shall be joined by use of heat fusion technique or butt fusion resulting in a monolithic pipe. Friatic fusion welded couplings are also acceptable. All joints shall be fully restrained and as strong as the pipe in both tension and hydrostatic loading.
- E. Fittings: Fittings shall be molded from a polyethylene compound having a cell classification equal to or exceeding the compound used in the pipe or shall be manufactured using a polyethylene compound having a cell classification equal to or exceeding the compound used in the pipe supplied under this specification. All fittings supplied under this specification shall be of the same manufacturer as the pipe being supplied, unless electorfused couplings are used. Minimum cell classification shall be 345434 C as referenced in ASTM D 3350-84.

2.4 NONPRESSURE-TYPE TRANSITION COUPLINGS

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 1. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 2. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
- D. Ring-Type, Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.5 BACKWATER VALVES

A. Cast-Iron Backwater Valves:

1. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
2. Horizontal type; with swing check valve and hub-and-spigot ends.
3. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
4. Terminal type; with bronze seat, swing check valve, and hub inlet.

B. PVC Backwater Valves:

1. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

2.6 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
2. Sewer Pipe Fitting and Riser to Cleanout: ASTM A74, Service class, cast-iron soil pipe and fittings.

B. PVC Cleanouts:

1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.7 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches minimum unless otherwise indicated.

3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
4. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
5. Riser Sections: 4-inch minimum thickness, of length to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual FRP steps, or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches .
10. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6 to 12-inch total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch ID by 7- to 9-inch riser, with 4-inch minimum-width flange and 26-inch diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
2. Material: ASTM A 536, Grade 60-40-18 ductile iron unless otherwise indicated.

C. Manhole-Cover Inserts:

1. Description; Manufactured, plastic form, of size to fit between manhole frame and cover and designed to prevent stormwater inflow. Include handle for removal and gasket for gastight sealing.
2. Type: Drainage with vent holes.

2.8 CONCRETE

A. General: Cast-in-place concrete complying with ACI 318, ACI 350 (ACI 350M), and the following:

1. Cement: ASTM C150/C150M, Type II.
2. Fine Aggregate: ASTM C33/C33M, sand.
3. Coarse Aggregate: ASTM C33/C33M, crushed gravel.

4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.
 1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
 1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - a. Invert Slope: 1 percent through manhole.
 2. Benches: Concrete, sloped to drain into channel.
 - a. Slope: 4 percent.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.
 1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves,

and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure, drainage piping according to the following:
 - 1. Install piping [NPS 6 (DN 150)] <Insert pipe size> and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 - 2. Install ABS sewer piping according to ASTM D2321 and ASTM F1668.
 - 3. Install PVC Type PSM sewer piping according to ASTM D2321 and ASTM F1668.
- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure, drainage piping according to the following:
 - 1. Join ABS sewer piping according to ASTM D2321 for elastomeric-seal joints.
 - 2. Join PVC Type PSM sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
 - 3. Join dissimilar pipe materials with nonpressure-type, flexible couplings.
 - 4. HDPE Joining:
 - a. Butt-fused Joint
 - 1) The polyethylene pipe shall be assembled and joined at the site using the butt-fusion method to provide a leak proof joint. Socket fusion, extrusion welding or hot gas welding, threaded or solvent cement joints and connections are not permitted. All equipment and procedures used shall be used in strict compliance with the manufacturer's recommendations. Fusion shall be accomplished by personnel certified as fusion technicians by a manufacturer of polyethylene pipe and/or fusing equipment. Certifications for all personnel shall be submitted to JCW prior to the inspection of the work.
 - 2) The butt-fused joint shall have true alignment and uniform roll back beads resulting from the use of proper temperature and pressure. The

joint shall be allowed adequate cooling time before removal of the pressure. The fused joint shall be water tight and shall have tensile strength equal to that of the pipe and shall indicate a ductile rather than brittle fracture when tested. All defective joints shall be cut out and replaced. Any section of the pipe with a gash, blister, abrasion, nick, scar, or other deleterious fault greater in depth than five percent (5%) of the wall thickness, shall not be used and must be removed from the site. However, a defective area of the pipe may be cut out and the joint fused in accordance with the procedures stated above. In addition, any section of the pipe having other defects such as concentrated ridges, discoloration, excessive spot roughness, pitting, variable wall thickness or any other defect of manufacturing or handling in the opinion of JCW shall be discarded and not used.

- 3) Butt fusion beads shall be uniform on both sides of the joint (i.e. no wrinkles or discontinuities).
- 4) All internal beads shall be removed after the cooling time using a suitable bead removal tool from the manufacturer. The bead removal tool shall not induce any slits, gouges or defects in the pipe wall.
- 5) After the pipe has been successfully joined, the installer shall place the pipe in the trench and haunch the pipe.

b. Electrofusion Joints:

- 1) HDPE joining using electrofusion couplings shall be witnessed by Inspection
- 2) Pipe edges shall be chamfered and the pipe interior and exterior shall be cleaned and pipe shall be rounded as recommended by the manufacturer.
- 3) The oxide layer of the pipe shall be removed using a scraper tool from the manufacturer. Files, rasps, sandpaper and other similar tools shall not be used.
- 4) Pipe shall be inserted in the coupling for final connection in a manner to ensure a stress-free assembly of the component parts.
- 5) The coupling shall be connected by fusion leads to the electrofusion unit and the fusion process shall be recorded, completed and documented as required by the manufacturer.
- 6) Joint shall be allowed to cool as recommended by the manufacturer before moving or placing any stress on the joint.
- 7) All defective joints shall be removed and replaced.

- B. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.

- B. Install precast concrete manhole sections with sealants according to ASTM C891.
- C. Install FRP manholes according to manufacturer's written instructions.
- D. Form continuous concrete channels and benches between inlets and outlet.
- E. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
- F. Install manhole-cover inserts in frame and immediately below cover.

3.5 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318.

3.6 BACKWATER VALVE INSTALLATION

- A. Install horizontal-type backwater valves in piping manholes or pits.
- B. Install combination horizontal and manual gate-type valves in piping and in manholes.
- C. Install terminal-type backwater valves on end of piping and in manholes. Secure units to sidewalls.

3.7 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
 - 2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 - 3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 - 4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
- B. Set cleanout frames and covers in earth on cast-in-place-concrete block, 12 by 12 by 4 inches deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.8 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 221316 "Sanitary Waste and Vent Piping."
- B. Connect force-main piping to building's sanitary force mains specified in Section 221316 "Sanitary Waste and Vent Piping." Terminate piping where indicated.
- C. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - 3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of, and be flush with, inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.
 - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
 - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 - 4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.9 IDENTIFICATION

- A. Comply with requirements in Section 312000 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
 - 1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.10 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.
1. Submit separate report for each system inspection.
 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
1. Do not enclose, cover, or put into service before inspection and approval.
 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate report for each test.
 5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
 - a. Fill sewer piping with water. Test with pressure of at least 10-foot (3-m) head of water, and maintain such pressure without leakage for at least 15 minutes.
 - b. Close openings in system and fill with water.
 - c. Purge air and refill with water.
 - d. Disconnect water supply.
 - e. Test and inspect joints for leaks.
 6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Test plastic gravity sewer piping according to ASTM F1417.
 - b. Test concrete gravity sewer piping according to ASTM C1628.
 7. Manholes: Perform hydraulic test according to ASTM C969 (ASTM C969M).

- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.11 CLEANING

- A. Clean dirt and superfluous material from interior of piping.

END OF SECTION 221313

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sanitary Waste and Vent Piping
2. Condensate-drain piping
3. Pipe, tube, and fittings.
4. Specialty pipe fittings.

1.2 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 1. Condensate-Drain Piping: 150 deg F (66 deg C).

2.2 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.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

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. Shielded Couplings: Assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

2.4 ABS PIPE AND FITTINGS

- A. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
- B. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
- C. Solvent Cement: ASTM D 2235.
 1. ABS solvent cement shall have a VOC content of 325 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."

2.5 SANITARY WASTE & VENT PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

2.6 CONDENSATE DRAIN PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
- B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
 1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.7 JOINING MATERIALS

- A. Solvent Cements for Joining Plastic Piping:
 1. CPVC Piping: ASTM F 493.
 - a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
 - b. Adhesive primer shall have a VOC content of 550 g/L or less.
 - c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - a. PVC solvent cement shall have a VOC content of 510 g/L or less.
 - b. Adhesive primer shall have a VOC content of 550 g/L or less.
 - c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

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. Shielded, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of 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.

2.9 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. Hart Industries International, Inc.
 - e. Jomar International Ltd.
 - f. Matco-Norca.
 - g. Watts Regulator Co.
 - h. Victaulic Company Of America.
 - i. Zurn Industries, LLC.
- C. Dielectric Waterways
 1. 1/2 inch (DN15) through 4 inch (DN100) sizes, IPS to copper-tubing size dielectric transition fitting. Fittings shall be a copper-silicon casting conforming to UNS C87850, and UL classified in accordance with ANSI / NSF-61 for potable water service. Fittings shall have threaded ends, grooved ends, or a combination.

PART 3 - EXECUTION

3.1 PLENUM PIPING

- A. With the approval of the local jurisdiction, plastic piping as specified may be used and where located in return air plenums shall be wrapped with noncombustible insulation listed for plenum installation with a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84.

3.2 EARTH MOVING

- A. Comply with requirements in other sections of these specifications for excavating, trenching, and backfilling.

3.3 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 at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Make changes in direction for condensate drain, 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.

- I. 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.
- J. 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 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- K. 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."
- L. Install aboveground ABS piping according to ASTM D 2661.
- M. Install aboveground PVC piping according to ASTM D 2665.
- N. Install underground ABS and PVC piping according to ASTM D 2321.
- O. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 2. Install cleanouts located not more than 100 feet apart, at changes in direction greater than 45 degrees and at the base of each waste or soil stack.
 - 3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."
- P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors.
- R. Install sleeve seals for piping penetrations of concrete walls and slabs.
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

- T. Pipe indoor condensate drains to appropriate receptors as shown on the plans.
- U. Pipe outdoor condensate drains to nearest roof drain, downspout or other location as indicated on the plans. Do not spill on roof unless indicated on plans.

3.4 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

3.5 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. 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. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Plastic 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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.6 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, nonpressure transition couplings.

3.7 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 (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) 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 (300 mm) 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 (10-mm) minimum rods.
- E. Install hangers and supports for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 - 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 - 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 - 5. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
- G. Install hangers and supports for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1 and Smaller: Maximum span, 3 feet.

2. NPS 1-1/4 and Larger: Maximum span, 4 feet.
- H. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).
- I. Install hangers and supports for copper tubing with the following maximum spacing and minimum rod sizes:
 1. NPS 1-1/4 and Smaller: Maximum span, 6 feet; minimum rod size, 3/8 inch (10 mm).
 2. NPS 1-1/2 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch (10 mm).
- J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.8 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 in pit with pit cover flush with floor.
 6. Comply with requirements for backwater valves, cleanouts, and drains specified in Section 221319 "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 (DN 65) and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.9 IDENTIFICATION

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

3.10 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 (30 kPa). 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 (250 Pa). 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.

3.11 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.
- D. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.12 PIPING SCHEDULE

- A. Aboveground, soil and waste piping shall be one of the following:
 - 1. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints wrapped with noncombustible insulation listed for plenum installation.
- B. Underground, soil and waste piping shall be any of the following:
 - 1. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - 3. Or other owner pre-approved alternates
- C. Underground, grease waste piping within 20 feet of a fixture receiving waste from a dishwasher shall be the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. Or other owner pre-approved alternates
- D. Aboveground force mains shall be any of the following:
 - 1. Solid-wall schedule 40 ABS pipe, ABS socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
 - 2. Solid-wall schedule 40 PVC pipe, PVC socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
 - 3. Or other owner pre-approved alternates
- E. Above and below ground vent piping shall be any of the following:

1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
4. Or other owner pre-approved alternates

F. Condensate-Drain Piping:

1. Indoor Piping: Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints or pressure seal joints.
2. Outdoor Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
3. Or other owner pre-approved alternates

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backwater valves.
2. Cleanouts.
3. Floor drains.
4. Roof flashing assemblies.
5. Miscellaneous sanitary drainage piping specialties.
6. Flashing materials.

1.2 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Plastic Backwater Valves:

1. Size: Same as connected piping.
2. Body: ABS or PVC to match drain piping.
3. Cover: Same material as body with threaded access to check valve.
4. Check Valve: Removable swing check.
5. End Connections: Socket type.

2.2 CLEANOUTS

A. Exposed Cast-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.

- c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Wade
 - f. Watts Drainage Products.
 - g. Zurn Plumbing Products Group.
- 2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
 - 3. Size: Same as connected drainage piping
 - 4. Body Material: Hubless, cast-iron soil pipe test tee] as required to match connected piping.
 - 5. Closure: Countersunk cast-iron plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. Oatey.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Wade
 - g. Watts Drainage Products Inc.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.36.2M for adjustable housing cleanout.
- 3. Size: Same as connected branch.
- 4. Type: Cast-iron soil pipe with cast-iron ferrule.
- 5. Body or Ferrule: Cast iron.
- 6. Outlet Connection: Threaded.
- 7. Closure: Brass plug with tapered threads.
- 8. Adjustable Housing Material: Cast iron with threads.
- 9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
- 10. Frame and Cover Shape: Round.

C. Cast-Iron Wall Cleanouts:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.

- e. Wade
 - f. Watts Drainage Products Inc.
 - g. 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, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Commercial Enameling Co.
 - b. Josam Company; Josam Div.
 - c. MIFAB, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Wade
 - g. Watts Drainage Products Inc.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Pattern: Floor drain.
- 3. Outlet: Bottom.
- 4. Top or Strainer Material: Nickel bronze.
- 5. Trap Features: Trap-seal primer valve drain connection.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company; Elmdor/Stoneman Div.
 - b. Thaler Metal Industries Ltd.

2. Description: Manufactured assembly made of 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch- (1.6-mm-) thick, lead flashing collar and skirt extending at least 6 inches (150 mm) from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
 - a. Open-Top Vent Cap: Without cap.
 - b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
 - c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. 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 (DN 15) side inlet.

B. Barrier Type Floor Drain Trap Seal Protection Device

1. An ICC-ES certified product with HDPE housing with heavy duty silicone diaphragm and soft EPDM rubber sealing gasket complying with ASSE 1072-2007

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches (51 mm) above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

2.6 FLASHING MATERIALS

- A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
 1. General Use: 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.
 2. Vent Pipe Flashing: 3.0-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.
 3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.
- B. Fasteners: Metal compatible with material and substrate being fastened.
- C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- D. Solder: ASTM B 32, lead-free alloy.
- E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Where shown on the plans and where plumbing fixtures are installed on a floor with a finished floor elevation below the elevation of the manhole cover of the next upstream manhole in the public sewer, install backwater valves in building drain piping.
 1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
- B. 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 (DN 100). Use NPS 4 (DN 100) 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 of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 4. Locate 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 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 (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.
 - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- H. 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.
- I. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- J. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- K. Install vent caps on each vent pipe passing through roof.
- L. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 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. Install piping adjacent to equipment to allow service and maintenance.
- C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

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. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.
- 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 (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) 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 other sections of the specifications.
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.

- 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 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

SECTION 221319.13 – SANITARY DRAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor drains.
2. Floor sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall 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. Cast-Iron Floor Drains <**FD**>:

1. Basis of Design: J.R. Smith 2010
2. Pattern: Floor drain.
3. Body Material: Cast Iron.
4. Outlet: Bottom.
5. Top or Strainer Material: Bronze
6. Top Shape: Square.
7. Dimensions of Top or Strainer: 5 inches.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks <**FS-1, FS-2, FS-3**>:

1. Basis of Design: J.R. Smith 3100
2. Outlet: Bottom, connection.

3. Coating on Interior Surfaces: Acid-resistant enamel.
4. Internal Strainer: Dome.
5. Internal Strainer Material: Aluminum.
6. Top of Body and Grate Finish: Nickel bronze.
7. Top Shape: Square.
8. Top Grate: **FS-1** no grate, **FS-2** half grate, **FS-3** three-quarters grate

PART 3 - EXECUTION

3.1 INSTALLATION

- 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. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 2. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 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 221323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- C. Install piping adjacent to equipment to allow service and maintenance.

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 221319.13

SECTION 221323 – SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grease interceptors.
2. Oil interceptors.
3. Solids interceptors.
4. Precast-concrete manhole risers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of interceptor.

B. Shop Drawings: For each type and size of precast-concrete interceptor indicated.

1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

A. Precast-Concrete Grease Interceptors: Comply with ASTM C913 and the requirements of the authorities having jurisdiction.

1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
2. Structural Design Loads:
 - a. Heavy-Traffic Load: Comply with ASTM C890, A-16.
3. Steps: "Grade Rings" Subparagraph below is an optional feature.
4. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.

5. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID.
 - a. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.
 - b. Gray Iron: ASTM A48/A48M, Class 35, unless otherwise indicated.
6. Capacities and Characteristics:
 - a. To be calculated based on the requirements of the authority having jurisdiction, and/or the requirements of the code.

2.2 OIL INTERCEPTORS

- A. Precast Concrete Oil Interceptors: Comply with ASTM C913 and the authorities having jurisdiction.
 1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
 2. Structural Design Loads:
 - a. Heavy-Traffic Load: Comply with ASTM C890, A-16.
 3. Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into interceptor walls, for each pipe connection.
 4. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
 5. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum-width flange and 26-inch- (660-mm-) diameter cover.
 - a. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.
 - b. Gray Iron: ASTM A48/A48M, Class 35, unless otherwise indicated.
 6. Capacities and Characteristics:
 - a. Capacity: To be calculated based on the requirements of the authority having jurisdiction, and/or the requirements of the code.
 7. Extension: Cast-iron or steel shroud, full size of interceptor, extending from top of interceptor to grade.

2.3 PRECAST-CONCRETE MANHOLE RISERS

- A. Precast Concrete Manhole Risers: ASTM C478 (ASTM C478M), with rubber-gasket joints.
 1. Structural Design Loads:

- a. Heavy-Traffic Load: Comply with ASTM C890, A-16.
- 2. Length: From top of underground concrete structure to grade.
- 3. Riser Sections: 3-inch (75-mm) minimum thickness and 36-inch (915-mm) diameter.
- 4. Top Section: Eccentric cone unless otherwise indicated. Include top of cone to match grade ring size.
- 5. Gaskets: ASTM C443 (ASTM C443M), rubber.
- B. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, diameter matching manhole frame and cover, and height as required to adjust the manhole frame and cover to indicated elevation and slope.
- C. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum-width flange and 26-inch- (660-mm-) diameter cover.
 - 1. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.
 - 2. Gray Iron: ASTM A48/A48M, Class 35, unless otherwise indicated.
 - 3. Include indented top design with lettering cast into cover, using wording equivalent to the following:

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Install grease interceptors and solids interceptors on cast-in-place concrete equipment base(s).
- B. Install precast concrete interceptors according to ASTM C891.
- C. Set interceptors level and plumb.
- D. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.
- E. Set tops of manhole frames and covers flush with finished surface in pavements.
 - 1. Set tops 3 inches (75 mm) above finish surface elsewhere unless otherwise indicated.

- F. Set tops of grating frames and grates flush with finished surface.
- G. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.
- H. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet.
 - 1. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

- A. Identification materials and installation are specified in Section 312000 "Earth Moving."
 - 1. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
 - 2. Use warning tapes or detectable warning tape over ferrous piping.
 - 3. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.5 PROTECTION

- A. Protect sanitary waste interceptors from damage during construction period.
- B. Repair damage to adjacent materials caused by sanitary waste interceptor installation.

END OF SECTION 221323

SECTION 221329 - SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sewage pumps.
2. Wet-pit-volute sewage pumps.
3. Sewage-pump basins and basin covers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SEWAGE PUMPS

A. Submersible Sewage Pumps:

1. Description: Factory-assembled and -tested sewage-pump unit.
2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
4. Impeller: Statically and dynamically balanced, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
5. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
6. Seal: Mechanical.
7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
8. Controls:
 - a. Enclosure: NEMA 250, Type 4X.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
9. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.

2.3 SEWAGE-PUMP BASINS AND BASIN COVERS

- ### A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
1. Material: Fiberglass or Polyethylene.
 2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.

3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
- B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
 2. Cover Material: Cast iron.
 3. Cover Diameter: Not less than outside diameter of basin top flange.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Pump Installation Standards:
 1. Comply with HI 1.4 for installation of centrifugal pumps.
 2. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.
- B. 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.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.3 FIELD QUALITY CONTROL

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

- B. Pumps and controls will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 221329

SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. ABS pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe and fittings.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 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 (30 kPa).

2.2 ABS PIPE AND FITTINGS

A. NSF Marking: Comply with NSF 14, "Plastics Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

B. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.

C. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.

- D. Solvent Cement: ASTM D 2235.

2.3 PVC PIPE AND FITTINGS

- A. NSF Marking: Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
- B. Solid-Wall PVC Pipe: ASTM D 2665; drain, waste, and vent.
- 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.
- E. Solvent Cement: ASTM D 2564.

2.4 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. General Requirements: Fitting or device for joining piping with small differences in ODs 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, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1173.
 - b. Description: Elastomeric sleeve, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - c. Sleeve Materials:
 - 1) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 2) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 - 4. Shielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1460.
 - b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 - 2. 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. Install seismic restraints on piping. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
 - 1. Do not change direction of flow more than 90 degrees.
 - 2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of drainage piping in direction of flow is prohibited.
- K. Lay buried building piping beginning at low point of each system.
 - 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 - 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

3. Maintain swab in piping and pull past each joint as completed.
- L. Install piping at the following minimum slopes unless otherwise indicated:
 1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 2. Horizontal Storm Drainage Piping: 2 percent downward in direction of flow.
- M. Install aboveground ABS piping according to ASTM D 2661.
- N. Install aboveground PVC piping according to ASTM D 2665.
- O. Install underground ABS and PVC piping according to ASTM D 2321.
- P. Plumbing Specialties:
 1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.
 2. Install drains in storm drainage gravity-flow piping.
- Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors.
- S. Install sleeve seals for piping penetrations of concrete walls and slabs.
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs.
 1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

- A. ABS and PVC, Nonpressure-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 appendices.
 - 3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendices.
 - 4. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
 - 5. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
 - 6. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
 - 7. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.3 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in ODs.

3.4 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
- D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere unless otherwise indicated.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for hangers, supports, and anchor devices 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 (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Install hangers for cast-iron soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for ABS and PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting[, valve,] and coupling.
- F. Support vertical cast-iron soil piping with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent, but as a minimum at base and at each floor.
- G. Support vertical ABS and PVC piping with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 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.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

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

3.8 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. 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.
 - a. 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.
 - a. Expose work that was covered or concealed before it was tested.
 3. Test Procedure:
 - a. Test storm drainage piping on completion of roughing-in.
 - b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). 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.

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

D. Prepare test and inspection reports.

3.9 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.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Storm drainage piping shall be any of the following:

1. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Or other owner pre-approved alternates

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roof drains.
2. Miscellaneous storm drainage piping specialties.
3. Cleanouts.
4. Flashing materials.

1.2 ACTION SUBMITTALS

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

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

- A. Josam Company; Josam Div.
- B. MIFAB, Inc.
- C. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- D. Tyler Pipe; Wade Div.
- E. Wade
- F. Watts Drainage Products Inc.
- G. Zurn Plumbing Products Group; Light Commercial Operation.

- H. Zurn Plumbing Products Group; Specification Drainage Operation.

2.2 METAL ROOF DRAINS

A. Cast-Iron General-Purpose Roof Drains:

1. Standard: ASME A112.6.4, for general-purpose roof drains.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 14-inch diameter.
4. Outlet: Bottom.
5. Underdeck Clamp: Required.
6. Sump Receiver Plate: Required.
7. Dome Material: Cast iron.
8. Water Dam: 2 inches high (on overflow drains only).

2.3 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:

1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
2. Size: Inlet size to match parapet drain outlet.

B. Downspout Boots:

1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.

C. Downspout Nozzles:

1. Description: Bronze body with bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.4 CLEANOUTS

A. Floor Cleanouts:

1. Standard: ASME A112.36.2M, for threaded, adjustable housing cleanouts.
2. Size: Same as connected branch.
3. Type: Threaded, adjustable housing.
4. Body or Ferrule Material: Cast iron
5. Outlet Connection: Threaded.
6. Closure: Brass plug with tapered threads.

7. Adjustable Housing Material: Cast iron.
8. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
9. Frame and Cover Shape: Round.

B. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
2. Size: Same as connected drainage piping.
3. 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.
4. Closure Plug: Countersunk.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
2. Size: Same as connected drainage piping.
3. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure: Countersunk plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Wall Access: Round, deep, chrome-plated bronze cover plate with screw.
7. Wall Access: Round wall-installation frame and cover.

2.5 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) 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 downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
- C. Install downspout boots at grade with top 6 inches (152 mm) above grade. Secure to building wall.
- D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- E. 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 (DN 100). Use NPS 4 (DN 100) 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 (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 - 4. Locate cleanouts at base of each vertical stack.
- F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- H. Install test tees in vertical conductors and near floor.
- I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- J. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- K. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

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

3.3 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. (30-kg/sq. m) lead sheets, 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of 4.0-lb/sq. ft. (20-kg/sq. m) lead sheets, 0.0625-inch (1.6-mm) 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 (250 mm) and with skirt or flange extending at least 8 inches (200 mm) around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) 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.

3.4 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 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Submersible sump pumps.
 - 2. Sump-pump basin covers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. All pumps must have a pump efficiency index (PEI) less than or equal to one where required per DOE regulations.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1 year labor warranty.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

- A. Submersible, Fixed-Position, Single-Seal Sump Pumps:
 - 1. Description: Factory-assembled and -tested sump-pump unit.
 - 2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump.
 - 3. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - 4. Impeller: Statically and dynamically balanced, design for clear wastewater handling, and keyed and secured to shaft.
 - 5. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
 - 6. Seal: Mechanical.
 - 7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
- B. Controls:
 - 1. Enclosure: NEMA Type 4X wall-mounted 115 V single phase control panel with:
 - a. 20 foot piggyback electrical supply cord
 - b. Audible and light alarms with dry contacts
 - c. Preset 'on' and 'off' points and ability to differentiate oil and water
 - d. Alarm test and silence switches

- e. 304 Stainless steel probes
 - 2. Control-Interface Features:
 - a. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
- 2.2 SUMP PUMP CAPACITIES AND CHARACTERISTICS
- A. As indicated on the equipment schedule on the plans.
- 2.3 SUMP-PUMP BASIN COVERS
- A. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - B. Capacities and Characteristics:
 - 1. As indicated on the equipment schedule on the plans.
- 2.4 MOTORS
- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors appropriate for the proposed service.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Pumps and controls will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 ADJUSTING

- A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

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.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for commercial domestic-water heaters, accessories, and components, from manufacturer.
- B. Product Certificates: For each type of 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.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Electric, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Five years.
 - b. Expansion Tanks: Five 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 shall 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."
 - 2. Component Importance Factor: 1.0.
- 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. Standard: UL 1453.
2. Storage-Tank Construction: ASME-code (if 120 gallon or more), steel.
 - 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 (1035 kPa).
 - c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
3. 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.
4. Special Requirements: NSF 5 construction.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. 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.
2. 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.
- 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 (DN 20) with ASME B1.20.1 pipe threads.
- C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.
- D. Heat-Trap Fittings: ASHRAE/IES 90.1.
- E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.
- F. 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.
- G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.
- H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- I. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- J. 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 (457 mm) above the floor.
- K. 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 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 (450-mm) 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. 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 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
- C. 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."
- D. 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.

- E. 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."
- F. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- G. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- H. 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 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- I. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- J. Fill electric, domestic-water heaters with water.
- K. Charge domestic-water expansion tanks with air to required system pressure.
- L. 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 shall contain less than 0.25 percent of lead by weight.
- M. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

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 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Perform tests and inspections.
- 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.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain electric, domestic-water heaters.
- B. END OF SECTION 223300

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

1.1 SUMMARY

A. Section Includes:

1. Wall-mounted water closets.
2. Flushometer valves
3. Toilet seats.
4. Supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets, Wall Mounted, Top Spud, Accessible <WC-1>:

1. Bowl:
 - a. Basis of Design: Sloan Model ST-2459
 - b. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - c. Material: Vitreous china.
 - d. Type: Siphon jet.
 - e. Style: Flushometer valve.
 - f. Height: Refer to architectural details and plans for heights and locations of accessible and non-accessible fixtures.
 - g. Rim Contour: Elongated.
 - h. Water Consumption: 1.28 gal. (4.8 L) per flush.
 - i. Spud Size and Location: NPS 1-1/2 (DN 40); top.
2. Lever-Handle, Diaphragm Flushometer Valves:

- a. Basis of Design: Sloan Royal Model 111-1.28
 - b. Standard: ASSE 1037.
 - c. Minimum Pressure Rating: 125 psig (860 kPa).
 - d. Features: Include integral check stop and backflow-prevention device.
 - e. Material: Brass body with corrosion-resistant components.
 - f. Exposed Flushometer-Valve Finish: Chrome plated.
 - g. Style: Exposed.
 - h. Consumption: 1.28 gal. (4.8 L) per flush.
 - i. Minimum Inlet: NPS 1 (DN 25).
3. Toilet Seat:.
- a. Standard: IAPMO/ANSI Z124.5.
 - b. Material: Plastic.
 - c. Type: Commercial (Heavy duty).
 - d. Shape: Elongated rim, open front.
 - e. Hinge: Self-sustaining, check.
 - f. Hinge Material: Noncorroding metal.
 - g. Seat Cover: Not required.
 - h. Color: White.
4. Support: Water closet carrier:
- a. Standard: ASME A112.6.1M
 - b. Description: Extra Heavy Duty combination carrier to support minimum 750 lbs, designed for wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, compact or regular, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Water-Closet Installation:

- 1. Install level and plumb according to roughing-in drawings.
- 2. Install non-accessible, wall-mounted water closets at mounting height indicated in the architectural details
- 3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

- 1. Use carrier supports with waste-fitting assembly and seal.

2. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.

3.2 CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.3 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.

3.4 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-hung urinals.
2. Urinal flushometer valves.
3. Supports.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals - Wall Hung, Back Outlet, Washout: <UR-1>.

1. Fixture:

- a. Basis of Design: Sloan SU-1009-A
- b. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5/CSA B45.15.
- c. Material: Vitreous china.
- d. Type: Washout with extended shields.
- e. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
- f. Water Consumption: 0.125 gpf (0.5 Lpf).
- g. Spud Size and Location: NPS 3/4 (DN 20), top.
- h. Outlet Size and Location: NPS 2 (DN 50), back.
- i. Color: White.

2. Lever-Handle, Diaphragm Flushometer Valves:

- a. Basis of Design: Sloan Royal Model 186
 - b. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
 - c. Minimum Pressure Rating: 125 psig (860 kPa).
 - d. Features: Include integral check stop and backflow-prevention device.
 - e. Material: Brass body with corrosion-resistant components.
 - f. Exposed Flushometer-Valve Finish: Chrome plated.
 - g. Panel Finish: Chrome plated or stainless steel.
 - h. Style: [Exposed] [Concealed].
 - i. Consumption: 0.125 gal. (0.47 L) per flush.
 - j. Minimum Inlet: NPS 3/4 (DN 20).
3. Waste Fitting:
 - a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - b. Size: NPS 2 (DN 50).
 4. Support: Type I urinal carrier, with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.
 5. Urinal Mounting Height: Refer to architectural details and plans for heights and locations of accessible and non-accessible fixtures.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to rough-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install non-accessible, wall-mounted urinals at mounting height indicated in the architectural details
4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.

3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.

3.2 PIPING CONNECTIONS

- A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.3 ADJUSTING

- A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.4 CLEANING AND PROTECTION

- A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed urinals and fittings.
- C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vitreous-china, wall-mounted lavatories.
2. Manually operated lavatory faucets.
3. Supply fittings.
4. Waste fittings.
5. Lavatory supports.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- ##### A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- ##### A. Lavatory - Vitreous China, Wall Mounted, with Back <L-1>:

1. Fixture:
 - a. Basis of Design: Sloan SS-3005
 - b. Standard: ASME A112.19.2/CSA B45.1.
 - c. Type: For wall hanging.
 - d. Nominal Size: Rectangular, 22-3/8 by 19-3/4 inches.
 - e. Faucet-Hole Punching: Three holes, 4-inch (102-mm) centers.
 - f. Faucet-Hole Location: Top.
 - g. Color: White.
2. Faucet: F-1.
3. Support: Type II, concealed-arm lavatory carrier.

4. Lavatory Mounting Height: Refer to architectural details and plans for heights and locations of accessible and non-accessible fixtures.

2.2 MANUALLY OPERATED LAVATORY FAUCETS

- A. Lavatory faucets 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/NSF 372, or 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. Lavatory Faucets - Manual Type: Single-control mixing, <**F-1**>.
 1. Basis of Design: Chicago Faucets Model 2200-4CP
 2. Standard: ASME A112.18.1/CSA B125.1.
 3. Body Type: Centerset.
 4. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 5. Finish: Polished chrome plate.
 6. Maximum Flow Rate: 0.5 gpm (1.5 L/min.).
 7. Mounting Type: Deck, exposed.
 8. Valve Handle(s): Single lever.
 9. Spout: Rigid type.

2.3 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. 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.
- D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Wheel handle.
- F. Risers:
 1. NPS 3/8 (DN 10).
 2. ASME A112.18.6/CSA B125.6, braided- or corrugated-stainless steel, flexible hose riser.

2.4 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/4 (DN 32) offset and straight tailpiece.
 - a. Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 0.032-inch-(0.83-mm-) thick brass tube to wall and chrome-plated, brass or steel wall flange.

2.5 LAVATORY SUPPORTS

- A. Lavatory Carrier:
 - 1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lavatories level and plumb in accordance with roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install non-accessible, wall-mounted lavatories at mounting height indicated in the architectural details.
- D. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, in accordance with ICC A117.1.
- E. 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 220518 "Escutcheons for Plumbing Piping."
- F. 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."
- G. 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."

3.2 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.4 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 224216.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service sinks.
2. Kitchen/utility sinks.
3. Handwash sinks.
4. Manually operated sink faucets.
5. Supply fittings.
6. Waste fittings.
7. Sink supports.
8. Grout.

B. Related Requirements:

1. Section 114000 "Foodservice Equipment" for NSF-compliant foodservice and handwash sinks.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted sinks.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SERVICE SINKS

- A. Service Sinks - Molded Stone, Floor Mounted: <**MS-1**>.

1. Fixture:
 - a. Basis of Design: Fiat Model MSB-2424
 - b. Standard: ASME A112.18.2/CSA B125.2.
 - c. Shape: Square.
 - d. Nominal Size: 24 by 24 inches (610 by 610 mm).
 - e. Height: 10 inches (255 mm).
 - f. Rim Guard: On front top surfaces.
 - g. Drain: Grid with NPS 3 (DN 80) outlet.
2. Mounting: On floor and flush to wall.
3. Commercial Service Sink Faucets - Manual Type:
 - a. Basis of Design: Fiat Model 830 AA
 - b. Description: Wall/back mounted, brass body, with integral service stops, checks, spout with bucket/pail hook, 3/4-inch (20-mm) hose thread end, integral vacuum breaker, inlets 8 inches (200 mm) 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: Rough chrome plated.
 - 3) Handles: 4 arms.
 - 4) Brace: Adjustable top brace.

2.2 KITCHEN/UTILITY SINKS

A. Kitchen/Utility Sinks - Stainless Steel, Counter Mounted: <S-1>.

1. Basis of Design: Elkay LRAD 1919
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Type: Stainless steel, self-rimming, sound-deadened unit.
 - c. Number of Compartments: One.
 - d. Overall Dimensions: 19-1/2x19x6-1/2 deep.
 - e. Material: 18 gauge, Type 304 stainless steel.
 - f. Compartment:
 - 1) Dimensions: 16x13-1/2x6-1/2.
 - 2) Drain Location: Off centered right.
 - 3) Depth: Wheelchair accessible, 6-1/2".
3. Faucet(s):

- a. Sink faucets 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. Commercial Sink Faucets - Manual Type: Two-handle mixing.
 - 1) Basis of Design: Chicago Faucets 895-317CP
 - 2) Standard: ASME A112.18.1/CSA B125.1.
 - 3) General: Coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
 - 4) Body Type: Centerset.
 - 5) Body Material: Commercial, solid brass, or die-cast housing with brazed copper and brass waterway.
 - 6) Finish: Chrome plated.
 - 7) Maximum Flow Rate: 2.2 gpm (8.3 L/min).
 - 8) Mounting Type: Deck.
 - 9) Valve Handle(s): 4-inch (102-mm) wrist blade.
 - 10) Spout Type: 3-1/2" rigid gooseneck
 - 11) Spout Outlet: Aerator.
 - c. Number Required: One.
 - d. Mounting: On ledge.
4. Supply Fittings:
- a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - 1) Operation: Wheel handle.
 - 2) Risers: NPS 1/2 (DN 15), ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose.
5. Waste Fittings:
- a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Trap(s):
 - 1) Size: NPS 2 (DN 50).
 - 2) Material:
 - a) Chrome-plated, two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall; and chrome-plated brass or steel wall flange.
6. Mounting: On counter with sealant.

B. Kitchen/Utility Sinks - Stainless Steel, Counter Mounted: <S-2>.

1. Basis of Design: Elkay LRAD 3319
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Type: Stainless steel, self-rimming, sound-deadened unit.
 - c. Number of Compartments: Two.
 - d. Overall Dimensions: 33"x19"x6-1/2".
 - e. Material: 18 gauge, Type 304 stainless steel.
 - f. Each Compartment:
 - 1) Dimensions: 14"x14"x6-1/2".
 - 2) Drains: Grid with NPS 2 (DN 50) tailpiece and twist drain.
 - 3) Drain Location: Near back of compartment.
 - 4) Depth: Wheelchair accessible, 6-1/2".
3. Faucet(s):
 - a. Sink faucets 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. Commercial Sink Faucets - Manual Type: Two-handle mixing.
 - 1) Basis of Design: Chicago faucets 895-317GN8AE3CP
 - 2) Standard: ASME A112.18.1/CSA B125.1.
 - 3) General: Coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
 - 4) Body Type: Centerset.
 - 5) Body Material: Commercial, solid brass, or die-cast housing with brazed copper and brass waterway.
 - 6) Finish: Chrome plated.
 - 7) Maximum Flow Rate: 2.2 gpm (8.3 L/min).
 - 8) Mounting Type: Deck.
 - 9) Valve Handle(s): 4-inch (102-mm) wrist blade.
 - 10) Spout Type: 8" swivel gooseneck.
 - 11) Spout Outlet: Aerator.
 - c. Number Required: One.
 - d. Mounting: On ledge.
4. Supply Fittings:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.

- 1) Operation: Wheel handle.
 - 2) Risers: NPS 1/2 (DN 15), ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose.
5. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Trap(s):
 - 1) Size: NPS 2 (DN 50).
 - 2) Material:
 - a) Chrome-plated, two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall; and chrome-plated brass or steel wall flange.
6. Mounting: On counter with sealant.

2.3 HANDWASH SINKS

A. Handwash Sinks - Stainless Steel: <HS-1>.

1. Basis of Design: Advance Tabco Model 7-PS-50
2. Fixture:
 - a. Standards:
 - 1) ASME A112.19.3/CSA B45.4.
 - 2) NSF 61.
 - b. Type: Wall-mounted stainless steel basin with radius corners, back for faucet, and support brackets.
 - c. Overall Dimensions: 10 by 14 by 5 inches.
 - d. Material: 18 gauge, Type 304 stainless steel.
3. Faucet:
 - a. Sink faucets 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. Commercial Sink Faucets - Manual Type: Two-handle mixing.
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) General: Coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.

- 3) Body Material: Commercial, solid brass, or die-cast housing with brazed copper and brass waterway.
- 4) Finish: Chrome plated.
- 5) Maximum Flow Rate: 2.2 gpm (8.3 L/min).
- 6) Mounting Type: Backsplash mounted.
- 7) Valve Handle(s): 4-inch (102-mm) wrist blade.
- 8) Spout Type: Rigid gooseneck.
- 9) Spout Outlet: Aerator.
4. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
5. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
6. Support: Type II sink carrier.
7. Mounting Height: Refer to architectural plans and details for mounting heights.

2.4 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. 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.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Wheel handle.
- F. Risers:
 1. NPS 1/2 (DN 15).
 2. ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose.

2.5 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece.
- C. Trap:
 1. Size: NPS 1-1/2 (DN 40).
 2. Material:

- a. Chrome-plated, [two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall] [two-piece, cast-brass trap and ground-joint swivel elbow with 17-gauge brass tube to wall] [one-piece, cast-brass trap with swivel 17-gauge tubular brass wall bend] <Insert trap type>; and chrome-plated brass or steel wall flange.

2.6 SINK SUPPORTS

A. Sink Carrier:

1. Standard: ASME A112.6.1M.

2.7 GROUT

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install sinks level and plumb in accordance with rough-in drawings.
- B. Install supports, affixed to building substrate, for wall-hung sinks.
- C. Install wall-mounted sinks at height indicated on the architectural plans and details.
- D. Install wall-mounted sinks at accessible mounting height in accordance with ICC A117.1.
- E. Set floor-mounted sinks in leveling bed of cement grout.
- F. Install water-supply piping with stop on each supply to each sink faucet.
 1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
 2. Install stops in locations where they can be easily reached for operation.

- G. 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 220518 "Escutcheons for Plumbing Piping."
- H. Seal joints between sinks and 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."
- I. 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."

3.2 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.4 CLEANING AND PROTECTION

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224223 - COMMERCIAL SHOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shower heads and shower valves.
2. Grout.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. 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.

2.2 SHOWER HEADS AND SHOWER VALVES

A. Shower Head with Single-Handle, Pressure-Balancing Mixing Valve: <SH-1>.

1. Basis of Design: Symmons Model C-96-1-295-X-A-VP
2. Description: Single metal lever handle, accessible, pressure-balancing mixing valve with standard 1.5 gpm shower head.
3. Shower Valve:
 - a. Body Material: Solid brass.

- b. Finish: Polished chrome plate.
 - c. Mounting: Concealed.
 - d. Operation: Single-handle, twist or rotate control.
 - e. Antiscald Device: Integral with mixing valve.
 - f. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - 4. Supply Connections: NPS 1/2 (DN 15).
 - 5. Shower Head:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Type: Ball joint with arm and flange
 - c. Shower Head Maximum Flow Rate: 1.5 gpm (5.7 L/min.).
 - d. Shower Head Material: Metallic with chrome-plated finish.
 - e. Spray Pattern: Fixed.
 - 6. Drain:
 - a. Provide a floor drain FD-1 at each shower.
- B. Accessible Shower Head with Handheld Head, Single-Handle, Pressure-Balancing Mixing Valve: <**SH-2**>.
- 1. Basis of Design: Symmons C-96-500-B30-V-QD
 - 2. Description: Single-handle, accessible, pressure-balancing mixing valve with hose with handheld shower head on sliding rod shower head.
 - 3. Shower Valve:
 - a. Body Material: Solid brass.
 - b. Finish: Polished chrome plate.
 - c. Mounting: Concealed.
 - d. Operation: Single-handle, twist or rotate control.
 - e. Antiscald Device: Integral with mixing valve.
 - f. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - 4. Supply Connections: NPS 1/2 (DN 15).
 - 5. Shower Head:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Type: Ball joint with arm and flange.
 - c. Shower Head Maximum Flow Rate: 1.5 gpm (5.7 L/min.).
 - d. Shower Head Material: Metallic with chrome-plated finish.
 - e. Spray Pattern: Fixed.
 - 6. Drain:
 - a. Provide a floor drain FD-1 at each shower.
- C. Shower Head with Single-Handle, Pressure-Balancing Mixing Valve: <**SH-1**>.
- 1. Basis of Design: Symmons Model C-96-1-295-X-A-VP

2. Description: Single metal lever handle, accessible, pressure-balancing mixing valve with standard 1.5 gpm shower head.
3. Shower Valve:
 - a. Body Material: Solid brass.
 - b. Finish: Polished chrome plate.
 - c. Mounting: Concealed.
 - d. Operation: Single-handle, twist or rotate control.
 - e. Antiscald Device: Integral with mixing valve.
 - f. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
4. Supply Connections: NPS 1/2 (DN 15).
5. Shower Head:
 - a. Vandal resistant institutional head
 - b. Standard: ASME A112.18.1/CSA B125.1.
 - c. Type: Ball joint with arm and flange
 - d. Shower Head Maximum Flow Rate: 1.5 gpm (5.7 L/min.).
 - e. Shower Head Material: Metallic with chrome-plated finish.
 - f. Spray Pattern: Fixed.
6. Drain:
 - a. Provide a floor drain FD-1 at each shower.

2.3 GROUT

- A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble shower components according to manufacturers' written instructions.
- B. Install showers level and plumb.
- C. Install ball or gate valves in water-supply piping to the shower if supply stops are specified with the shower valve.

- D. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
- F. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.2 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with traps and soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ADJUSTING

- A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.
- B. Adjust water pressure at shower valves to produce proper flow.

3.4 CLEANING AND PROTECTION

- A. After completing installation of showers, inspect and repair damaged finishes.
- B. Clean showers, shower valves, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed fixtures and fittings.
- D. Do not allow use of showers for temporary facilities unless approved in writing by Owner.

END OF SECTION 224223

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Linear wash fountains.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of wash fountain.

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SOLID-SURFACE, LINEAR WASH FOUNTAINS

A. Wash Fountains <**WF-1**>: Solid-surface, linear (side-by-side) receptor.

1. Basis of Design: Bradle Corp model LVRD3
2. Standard: ASME A112.18.1/CSA B125.1.
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. Bowl(s) and Counter:
 - a. Height to Rim: See architectural details and plans for mounting heights.
 - b. Color or Finish: To be determined during submittal review phase.
 - c. Number of Bowls: One.
 - d. Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.

5. Faucets:
 - a. Bradley Corp Model S53-3100, Verge Faucet – Crestt Series
 - 1) Quantity: (3) Three
 - 2) Activation: Touch-Free
 - 3) Flow Control: 0.50 GPM
 - 4) Supply Type: Thermostatic Mixing Assembly
6. Supply Fittings:
 - a. Piping: NPS 1/2 (DN 15) copper tubing, each bowl.
 - b. Valves: Shutoff valve on each supply.
 - c. Supply Piping: From wall.
7. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Trap and Drain Piping: NPS 1-1/2 (DN 40), each bowl.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install wash fountains level and plumb according to roughing-in drawings.
- B. Install off-floor carrier supports, affixed to building substrate, for wall-mounted wash fountains.
- C. Install accessible, wall-mounted wash fountains at mounting height for handicapped/elderly according to ICC A117.1.
- D. Install water-supply piping with shutoff valve on each supply to each wash fountain to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation.
- E. Install trap and waste piping on each drain outlet of each wash fountain to be connected to sanitary drainage system.
- F. 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 220518 "Escutcheons for Plumbing Piping."
- G. 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."

3.2 CONNECTIONS

- A. Connect wash fountains with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
- C. Comply with requirements for soil and waste drainage piping and vent piping specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ADJUSTING

- A. Operate and adjust wash fountains and controls. Replace damaged and malfunctioning wash fountains, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.4 CLEANING AND PROTECTION

- A. After installing wash fountains, inspect and repair damaged finishes.
- B. Clean wash fountains, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed wash fountains and fittings.
- D. Do not allow use of wash fountains for temporary facilities unless approved in writing by Owner.

END OF SECTION 224233

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency showers.
2. Eyewash equipment.
3. Eye/face wash equipment.
4. Combination units.
5. Water-tempering equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

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

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. ISEA Standard: Comply with ISEA Z358.1.
- C. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.
- D. Regulatory Requirements: Comply with requirements in ICC A117.1, ; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

2.2 EMERGENCY SHOWERS

- A. Freestanding, Plumbed Emergency Showers, <ES-1>:
 - 1. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
 - 2. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
 - 3. Control-Valve Actuator: Pull rod.
 - 4. Shower Head: 8-inch- (200-mm-) minimum-diameter, plastic.
 - 5. Mounting: Pedestal.

2.3 EYE/FACE WASH EQUIPMENT

- A. Accessible, Freestanding, Plumbed Eye/Face Wash Units, <EW-1>:
 - 1. Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
 - 2. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - 3. Control-Valve Actuator: Paddle.
 - 4. Spray-Head Assembly: Two or four receptor-mounted spray heads.
 - 5. Receptor: Plastic bowl.
 - 6. Drain Piping:
 - a. Size: NPS 1-1/4 (DN 32) minimum.
 - b. Finish: Chrome-plated brass.
 - c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.
 - 7. Drain Piping: Include galvanized-steel indirect connection to drainage system.

8. Mounting: Pedestal.

2.4 COMBINATION UNITS

A. Accessible, Plumbed Emergency Shower with Eyewash Combination Units, <EWS-1>:

1. Shower:

- a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
- b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
- c. Control-Valve Actuator: Pull rod.
- d. Shower Head: 8-inch- (200-mm-) minimum diameter, plastic.
- e. Mounting: Pedestal.

2. Eyewash Unit:

- a. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
- b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
- c. Control-Valve Actuator: Paddle.
- d. Spray-Head Assembly: Two receptor-mounted spray heads.
- e. Receptor: Plastic bowl.
- f. Mounting: Attached shower pedestal.

2.5 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:

1. Description: Factory-fabricated equipment with thermostatic mixing valve.

- a. Thermostatic Mixing Valve: Designed to provide 80 deg F (27 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
- b. Supply Connections: For hot and cold water.

2.6 SOURCE QUALITY CONTROL

- ### A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 INSTALLATION OF EMERGENCY PLUMBING FIXTURE

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- F. Install thermometers in supply and outlet piping connections to water-tempering equipment.
- G. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system.
- H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 CONNECTIONS

- A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment.
- B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.
- C. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping.
- D. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
- E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.3 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust or replace fixture flow regulators for proper flow.
- B. Adjust equipment temperature settings.

END OF SECTION 224500

SECTION 224716 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure water coolers.
2. Bottle filling stations.
3. Supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler and bottle filling station.

B. Shop Drawings:

1. Include diagrams for power wiring.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Pressure water coolers and bottle filling stations intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
2. Comply with ASHRAE 34 for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
3. Comply with UL 399.
4. Comply with ASME A112.19.3/CSA B45.4.

5. 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. Comply with NSF 42 and NSF 53 for water filters for water coolers and bottle filling stations.
7. Comply with ICC A117.1 for accessible water coolers and bottle filling stations.

2.2 PRESSURE WATER COOLERS

A. Pressure Water Coolers - Surface Wall-Mounted, Stainless Steel, Single Station with bottle filler: <EC-1>.

1. Basis of Design: Elkay EMABF8WSSK
2. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
3. Control: Push bar.
4. Bottle Filler: Sensor activation, with automatic shutoff timer:
5. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
6. Supply: NPS 3/8 (DN 10) with shutoff valve.
7. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
8. Filter: One or more water filters with capacity sized for unit peak flow rate.
9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
10. Support: Water-cooler carrier.
11. Water-Cooler Mounting Height: Refer to architectural plans and details for mounting heights.
12. Capacities and Characteristics:
 - a. Cooled Water: 8 gph (0.0084 L/s).
 - b. Ambient-Air Temperature: 90 deg F (32 deg C).
 - c. Inlet-Water Temperature: 80 deg F (27 deg C).
 - d. Cooled-Water Temperature: 50 deg F (10 deg C).
 - e. Electrical Characteristics:
 - 1) Volts: 120 V ac.
 - 2) Phase: Single.
 - 3) Hertz: 60 Hz.

B. Pressure Water Coolers - Surface Wall-Mounted, Stainless Steel, Dual Station, Bi-Level with bottle filler: <EC-2>.

1. Basis of Design: Elkay EZSTL8WSSK
2. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
3. Control: Push bar.
4. Bottle Filler: Sensor activation, with automatic shutoff timer:
5. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
6. Supply: NPS 3/8 (DN 10) with shutoff valve.

7. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
8. Filter: One or more water filters with capacity sized for unit peak flow rate.
9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
10. Support: Water-cooler carrier.
11. Water-Cooler Mounting Height: Refer to architectural plans and details for mounting heights.
12. Capacities and Characteristics:
 - a. Cooled Water: 8 gph (0.0084 L/s).
 - b. Ambient-Air Temperature: 90 deg F (32 deg C).
 - c. Inlet-Water Temperature: 80 deg F (27 deg C).
 - d. Cooled-Water Temperature: 50 deg F (10 deg C).
 - e. Electrical Characteristics:
 - 1) Volts: 120 V ac.
 - 2) Phase: Single.
 - 3) Hertz: 60 Hz.

PART 3 - EXECUTION

3.1 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 off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation.
- 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.
- F. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

3.2 PIPING CONNECTIONS

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

3.3 ELECTRICAL CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust pressure water-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 224716

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packed expansion joints.
2. Packless expansion joints.
3. Alignment guides and anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: 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.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKED EXPANSION JOINTS

- A. Slip-Joint Packed Expansion Joints SJ-01:
 - 1. Standard: ASTM F1007.
 - 2. Material: Carbon steel with asbestos-free PTFE packing.
 - 3. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
 - 4. Configuration: Single joint, Single joint with base, and double joint with base class(es), unless otherwise indicated.
 - 5. Slip Tube for sizes NPS 1-1/2 (DN 40) through NPS 16 (DN 400): Schedule 80.
 - 6. Sliding Surface: 2 mil thick chrome finish.
 - 7. End Connections: Flanged or welded ends to match piping system.

2.3 PACKLESS EXPANSION JOINTS

- A. Metal, Compensator Pack-less Expansion Joints MCEJ-01:
 - 1. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
 - 2. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
 - 3. Joint Axial Movement: 2 inches (50 mm) of compression and 1/2 inch (12 mm) of extension.
- B. Rubber Union Connector Expansion Joints RUEJ-01:
 - 1. Material: Twin reinforced-rubber spheres with external restraining cables.
 - 2. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
 - 3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- C. Flexible-Hose Pack-less Expansion Joints FHEJ-01:

1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
3. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
4. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged or welded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides **AG-01**:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

- b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
- c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install packed-type expansion joints with packing suitable for fluid service.
- C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one or two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
1. Anchor Attachment to Steel Structural Members: Attach by welding.
 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR MECHANICAL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 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: Carbon steel.
 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

2.5 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- 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 1-inch (25-mm) 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 (50 mm) above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- 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 (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) 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 (50 mm) 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 grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, 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.

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Cast-iron wall sleeves, or Galvanized-steel wall sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:

- a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
- 5. Interior Partitions:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.

END OF SECTION 220517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- 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 piping and with OD that completely covers opening.
1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.

- c. Insulated Piping: One-piece, stamped-steel type.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
- 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: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

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

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 7-inch (178-mm) nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
8. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 THERMOWELLS

- A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.4 PRESSURE GAGES

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

1. Standard: ASME B40.100.
2. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Metal.
10. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass pipe with pipe threads.
- C. Valves: Brass ball, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- J. Install valve and syphon fitting in piping for each pressure gage for steam.
- K. Install permanent indicators on walls or brackets in accessible and readable positions.
- L. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlets and outlets of each chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units.
 - 4. Outside-, return-, supply-, and mixed-air ducts.

M. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water connection.
3. Suction and discharge of each pump.
4. Inlet and outlet of each hydronic coil in air-handling units.

3.2 ADJUSTING

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

3.3 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- B. Scale Range for Air Ducts: 0 to 100 deg F.

3.4 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range: 0 to 100 psi.

END OF SECTION 230519

SECTION 230523.11 – GLOBE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze globe valves.
2. Iron globe valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B16.18 for solder-joint connections.
 5. ASME B31.9 for building services piping valves.
- C. Refer to HVAC valve schedule articles for applications of valves.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.2 BRONZE GLOBE VALVES

A. Bronze Globe Valves, Class 125:

1. Description:

- a. Standard: MSS SP-80, Type 1.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
- d. Ends: Threaded or solder joint.
- e. Stem and Disc: TFE.
- f. Packing: Asbestos free.
- g. Handwheel: Malleable iron.

2.3 IRON GLOBE VALVES

A. Iron Globe Valves, Class 125:

1. Description:

- a. Standard: MSS SP-85, Type I.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: ASTM A126, gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: Bronze.
- f. Packing and Gasket: Asbestos free.
- g. Operator: Handwheel or chainwheel.

2.4 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. Include zinc or epoxy coating.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

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

- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for globe valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Throttling Service except Steam: Globe valves.
 - 2. Throttling Service, Steam: Globe valves.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125, with TFE disc, and with soldered or threaded ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125, with flanged ends.

END OF SECTION 230523.11

SECTION 230523.12 – BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 3. ASME B16.18 for solder-joint connections.
 4. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
1. Handlever: For quarter-turn valves smaller than NPS 4 (DN 100).
- H. Valves in Insulated Piping:

1. Include 2-inch (50-mm) stem extensions.
 2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
 3. Memory stops that are fully adjustable after insulation is applied.
- I. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

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

1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

3.3 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller: Bronze ball valves, two piece, with bronze trim, full port, threaded, solder, or press connection-joint ends.
 1. Valves may be provided with solder-joint ends instead of threaded ends.

END OF SECTION 230523.12

SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. High-performance butterfly valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B16.1 for flanges on iron valves.
 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 3. ASME B31.1 for power piping valves.
 4. ASME B31.9 for building services piping valves.
- C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- D. Valve Sizes: Same as upstream piping unless otherwise indicated.
- E. Valve Actuator Types:
1. Gear Actuator: For valves NPS 8 (DN 200) and larger.
 2. Handlever: For valves NPS 6 (DN 150) and smaller.
 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

- F. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:

1. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 150 psig (1035 kPa).
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - e. Seat: EPDM.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Aluminum bronze.

2.3 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 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.

3.3 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 24 (DN 65 to DN 600):
Aluminum-bronze disc, 200 CWP, and EPDM seat.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze swing check valves.
2. Iron swing check valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B16.18 for solder joint.
 5. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:

1. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B62, bronze.
 - e. Ends: Threaded.
 - f. Disc: TFE.

2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:

1. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with or disc.
 - b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring; metal-seat check valves.
- B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 - 2. Bronze swing check valves with TFE disc, Class 125.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Iron swing check valves with metal seats, Class 125.

END OF SECTION 230523.14

SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. RS Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE GATE VALVES

A. Bronze Gate Valves, RS, Class 125:

1. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Iron Gate Valves, OS&Y, Class 125:

1. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 - c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 - d. Body Material: ASTM A126, gray iron with bolted bonnet.
 - e. Ends: Flanged.
 - f. Trim: Bronze.
 - g. Disc: Solid wedge.
 - h. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

- ### A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
 2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for gate valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Gate valves.
- B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 4. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 5. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller: Bronze valves, RS, Class 125, with threaded ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, OS&Y, Class 125.

END OF SECTION 230523.15

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
2. Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

1. Trapeze pipe hangers.
2. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers 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 and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, 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 pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

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 copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

- 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.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi (688-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi (688-kPa) minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 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 (34.5-MPa), 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 shall be weight of supported components plus 200 lb (90 kg).

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-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 from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. 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 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. 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.
- O. Insulated Piping:
 - 1. Attach clamps and spacers to piping.

- a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) 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 (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) 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.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 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 because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 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 (40 mm).

3.6 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 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 finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems] and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

END OF SECTION 230529

SECTION 230548 – VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 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. Snubbers.
13. Restraints - rigid type.
14. Restraints - cable type.
15. Restraint accessories.
16. Post-installed concrete anchors.
17. Concrete inserts.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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.

C. Delegated-Design Submittal:

1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
 - a. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
 - b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
 - c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
 - d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
 - e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
 - f. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.
2. Seismic- and Wind-Restraint Detail Drawing:
 - 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 and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).

5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Welding certificates.
- C. Field quality-control reports.
- D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in [ASCE/SEI 7-05,] [ASCE/SEI 7-10,] [ASCE/SEI 7-16,] Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
 1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction.
 2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-10 or ASCE/SEI 7-16.
 3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
- E. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
 1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
 2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.

3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic- and wind-load Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to 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: an agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind- load control system.
 1. Seismic and Wind-Load Performance: Equipment shall withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7-10 or ASCE/SEI 7-16.
- B. Seismic Design Calculations:
 1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities.
 - a. Data indicated below to be determined by Delegated-Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
 - c. Building Occupancy Category IV.
 - d. Building Risk Category: IV.
 - e. Building Site Classification: D.

2. Calculation Factors, ASCE/SEI 7-16, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-16 unless otherwise noted. Any factors not listed shall be obtained by the Delegated-Design Contractor for each component.
 - a. Horizontal Seismic Design Force F_p : Value is to be calculated by Delegated-Design Contractor using Equation 13.3-1. Factors below must be obtained by Delegated-Design Contractor for this calculation.
 - 1) S_{DS} = Spectral Acceleration: 0.674. Value applies to all components on Project.
 - 2) a_p = Component Amplification Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 3) I_p = Component Importance Factor: To be obtained by the Delegated-Design Contractor for each component.
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from each component.
 - 5) R_p = Component Response Modification Factor: Obtain by Delegated-Design Contractor from each component.
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determine from Project Drawings for each component by Delegated-Design Contractor. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
 - b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-16, Paragraph 13.3.1.2.
 - c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
 - 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculated by Delegated-Design Contractor in accordance with ASCE/SEI 7-16, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A
 - 4) δ_{yA} = Deflection at Building Level y of Structure A
 - 5) δ_{yB} = Deflection at Building Level y of Structure B
 - 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 8) Δ_{aA} = Allowable Story Drift for Structure A

- 9) Δ_{aB} = Allowable Story Drift for Structure B
 - 10) h_{sx} = Story Height Used in the Definition of Allowable Drift Δ_a
- d. Component Fundamental Period T_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-16, Paragraph 13.3.3. Factors below must be obtained for this calculation:
- 1) W_p = Component Operating Weight: Determined by Contractor from Project Drawings and manufacturer's data.
 - 2) g = Gravitational Acceleration: 32.17 fps² (9.81 m/s²).
 - 3) K_p = Combined Stiffness of the Component, Supports, and Attachments: Determined by delegated-design seismic engineer.
3. Calculation Factors, ASCE/SEI 7-10, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-10 unless otherwise noted.
- a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-10, Equation 13.3-1. Factors below must be obtained by Delegated-Design Contractor for this calculation:
- 1) S_{DS} = Spectral Acceleration
 - 2) a_p = Component Amplification Factor
 - 3) I_p = Component Importance Factor
 - 4) W_p = Component Operating Weight: For each component. Obtain by Delegated-Design Contractor from equipment submittal.
 - 5) R_p = Component Response Modification Factor
 - 6) z = Height in Structure of Point of Attachment of Component for Base: Determined from Project Drawings for each component by Contractor. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for Base: Determine from Project Drawings by Delegated-Design Contractor.
- b. Vertical Seismic Design Force: Calculate by Delegated- Design Contractor using method explained in ASCE/SEI 7-10, Paragraph 13.3.1.
- c. Seismic Relative Displacement D_{pl} : Calculate by Delegated-Design Contractor using methods explained in ASCE/SEI 7-10, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
- 1) D_p = Relative Seismic Displacement that Each Component Must Be Designed to Accommodate: Calculate by Delegated-Design Contractor in accordance with ASCE/SEI 7-10, Paragraph 13.3.2.
 - 2) I_e = Structure Importance Factor: 1.5. Value applies to all components on Project.
 - 3) δ_{xA} = Deflection at Building Level x of Structure A
 - 4) δ_{yA} = Deflection at Building Level y of Structure A
 - 5) δ_{yB} = Deflection at Building Level y of Structure B

- 6) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data;
 - 7) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 8) Δ_{aA} = Allowable Story Drift for Structure A
 - 9) Δ_{aB} = Allowable Story Drift for Structure B
 - 10) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a
4. Calculation Factors, ASCE/SEI 7-05, Ch. 13 - Seismic Design Requirements for Nonstructural Components: All section, paragraph, equation, and table numbers refer to ASCE/SEI 7-05 unless otherwise noted.
- a. Horizontal Seismic Design Force F_p : Calculated by Delegated-Design Contractor by ASCE/SEI 7-05, Equation 13.3-1. Factors below must be obtained for this calculation.
 - 1) S_{DS} = Spectral Acceleration
 - 2) a_p = Component Amplification Factor
 - 3) I_p = Component Importance Factor
 - 4) W_p = Component Operating Weight: Obtain by Delegated-Design Contractor for each component from component submittal.
 - 5) R_p = Component Response Modification Factor
 - 6) z = Height in Structure of Point of Attachment of Component for the Base: Determine by Delegated-Design Contractor for each component from Project Drawings. For items at or below the base, "z" shall be taken as zero.
 - 7) h = Average Roof Height of Structure for the Base: Determine by Delegated-Design Contractor from Project Drawings.
 - b. Vertical Seismic Design Force: Calculated by Delegated-Design Contractor using method explained in ASCE/SEI 7-05, Paragraph 13.3.1.
 - c. Seismic Relative Displacement D_p : Calculated by Delegated-Design Contractor using methods explained in ASCE/SEI 7-05, Paragraph 13.3.2. Factors below must be obtained by Delegated-Design Contractor for this calculation:
 - 1) δ_{xA} = Deflection at Building Level x of Structure A
 - 2) δ_{yA} = Deflection at Building Level y of Structure A
 - 3) δ_{yB} = Deflection at Building Level y of Structure B
 - 4) h_x = Height of Level x to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 5) h_y = Height of Level y to which Upper Connection Point Is Attached: Determine for each component by Delegated-Design Contractor from Project Drawings and manufacturer's data.
 - 6) Δ_{aA} = Allowable Story Drift for Structure A
 - 7) Δ_{aB} = Allowable Story Drift for Structure B

- 8) h_{sx} = Story Height Used in the Definition of the Allowable Drift Δ_a : Obtain by Delegated-Design Contractor from each component.

C. Wind-Load Design Calculations:

1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7-10 or other wind-force calculation method required by authorities having jurisdiction. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is intended as referenced throughout the Section Text unless otherwise noted.
 - a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
 - b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
2. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-16, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
 - a. Risk Category: IV.
 - b. h = Mean Roof Height: Determine by Delegated-Design Contractor from Project Drawings.
 - c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI) K_d = Wind Directionality Factor: 0.85.
 - d. Exposure Category: D.
 - e. K_{zt} = Topographic Factor: 1.0.
 - f. K_e = Ground Elevation Factor: 1.0.
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.
 - h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor
 - i. q_z = Velocity Pressure: Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.

- j. q_h = Velocity Pressure: Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-16 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor
 - l. Enclosure Classification: To be determined by Delegated-Design Contractor.
 - m. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
3. Design wind pressure "p" for rooftop equipment is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-10, Ch. 30, PART 6: Building Appurtenances and Rooftop Structures and Equipment.
- a. Risk Category: IV.
 - b. h = Mean Roof Height: To be determined by Delegated-Design Contractor from the Project Drawings.
 - c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI)
 - d. K_d = Wind Directionality Factor: 0.85.
 - e. Exposure Category: D.
 - f. K_{zt} = Topographic Factor: 1.0.
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.
 - h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor.
 - i. q_z = Velocity Pressure at Height z : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - j. q_h = Velocity Pressure at Height h : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-10 Section 26.10.1 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor.
 - l. Enclosure Classification: To be determined by Delegated-Design Contractor.
 - m. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
4. Design Wind Force "F" for rooftop equipment and external sidewall-mounted equipment such as louvers is to be calculated by Delegated-Design Contractor using methods in ASCE/SEI 7-05, Ch. 6.
- a. I = Importance Factor: 1.0 or 1.5 To be determined by Delegated-Design Contractor.
 - b. h = Mean Roof Height: To be determined by Delegated-Design Contractor by reviewing the plans.

- c. V = Basic Wind Speed:
 - 1) 182 MPH (3,000 year MRI)
 - 2) 113 MPH (25 year MRI)
 - 3) 74 MPH (10 year MRI)
 - d. K_d = Wind Directionality Factor: 0.85.
 - e. Exposure Category: D.
 - f. K_{zt} = Topographic Factor: 1.0
 - g. K_z = Velocity Pressure Exposure Coefficient (Evaluated at Height z): To be determined by Delegated-Design Contractor.
 - h. K_h = Velocity Pressure Exposure Coefficient (Evaluated at Height h): To be determined by Delegated-Design Contractor.
 - i. q_z = Velocity Pressure at Height z : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source approved by authorities having jurisdiction.
 - j. q_h = Velocity Pressure at Roof Height h : Value calculated by delegated wind-load design contractor using methods detailed in ASCE/SEI 7-05 Section 6.5.10 or other source approved by authorities having jurisdiction.
 - k. G = Gust-Effect Factor: To be determined by Delegated-Design Contractor.
 - l. GC_{pi} = Internal Pressure Coefficient: To be determined by Delegated-Design Contractor.
 - m. GC_p = External pressure coefficient: To be determined by Delegated-Design Contractor.
 - n. C_f = Force Coefficient: Value determined by delegated wind-load design Contractor from ASCE/SEI 7-05, Figures 6-21 through 6-23 or other source approved by authorities having jurisdiction.
 - o. A_f = Projected area normal to the wind: except where C_f is specified for the actual surface area. Value determined by delegated wind-load design contractor from equipment submittal or manufacturer.
- D. Consequential Damage: Provide additional seismic and wind-force restraints for suspended plumbing components or anchorage of floor, roof or wall mounted plumbing components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential plumbing component will not cause the failure of any other essential architectural, mechanical or electrical building component.
- E. Fire/Smoke Resistance: Seismic- and wind-load-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 an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- F. Component Supports:
- 1. Load Ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.

2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6

2.2 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. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
4. Surface Pattern: Smooth, ribbed, or waffle pattern.
5. Load-bearing metal plates adhered to pads.
6. Sandwich-Core Material: Resilient and elastomeric.
 - a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts

1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

B. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts

1. Description: All-directional isolator with seismic 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.

2.5 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 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 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. 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 psig (3447 kPa).
 - b. Top housing with attachment and leveling bolt.

2.7 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 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

1. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
2. 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 psig (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

- ### A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- (13-mm-) 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 psig (3447 KPa) on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- (13-mm-) 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.

2.11 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods
 1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.

2.12 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression
 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 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. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

- A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Post-installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC. Preset concrete inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
 - 2. Anchors in Masonry: Design in accordance with TMS 402.
 - 3. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 4. Resilient Cushion: Maximum 1/4-inch (6-mm) air gap, and minimum 1/4 inch (6 mm) thick.

2.14 RESTRAINTS - RIGID TYPE

- A. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, 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.

2.15 RESTRAINTS - CABLE TYPE

- A. Seismic- and Wind-Load-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. All 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.

2.16 RESTRAINT ACCESSORIES

- 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.

2.17 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 - 1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- B. Provide post-installed concrete anchors that have been prequalified for use in seismic applications.
 - 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.
- C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW), which is not vibration isolated.
 - 1. Undercut expansion anchors are permitted.

2.18 CONCRETE INSERTS

- A. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.
- B. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes 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 Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

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

3.2 INSTALLATION OF VIBRATION-CONTROL, WIND-LOAD CONTROL, AND SEISMIC-RESTRAINT DEVICES

- A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.
- B. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- C. 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."
- D. Installation of vibration isolators, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- F. Equipment Restraints:
 - 1. Install seismic snubbers on HVAC 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).
 - 3. Install seismic-restraint, and wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- G. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- H. Install seismic- and wind-loadrestraint cables so they do not bend across edges of adjacent equipment or building structure.

- I. Install seismic- and wind-loadrestraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- K. 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.
- L. 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.
- M. Mechanical Anchor Bolts:
 - 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. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Provide flexible connections in piping systems where they cross structural seismic joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Perform tests and inspection[with the assistance of a factory-authorized service representative.
 - 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 3. 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.
 - 4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
 - 6. Test to 90 percent of rated proof load of device.
 - 7. Measure isolator restraint clearance.
 - 8. Measure isolator deflection.
 - 9. Verify snubber minimum clearances.
 - 10. Test and adjust restrained-air-spring isolator controls and safeties.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: stainless steel, 0.025-inch (0.64-mm) 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 (64 by 19 mm).
4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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, 1/8 inch (3.2 mm) 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 (71 deg C).
 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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, 1/8 inch (3.2 mm) 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 (71 deg C).
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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-taping 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 NFPA70E and other applicable codes and standards.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 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 main 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, and At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

2.4 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having 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 up to 160 deg F (71 deg C).
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- E. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), 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. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping and At least 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

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 mechanical equipment.
- B. Sign and Label Colors:
 1. White letters on an ANSI Z535.1 safety-blue 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 arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF PIPE LABELS

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting." Or Section 099600 "High-Performance Coatings."
- B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- C. 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. (1 m) 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. (1 m) of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 25 ft. (8 m) along each run. Reduce intervals to 10 ft. (3.0 m) in areas of congested piping, ductwork, and equipment.
- D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F (52 deg C) or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- E. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- F. Pipe-Label Color Schedule:
 - 1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 2. Refrigerant Piping: White letters on an ANSI Z535.1 safety-blue background.
 - 3. Potable and Other Water: White letters on an ANSI Z535.1 safety-green background.
 - 4. Include additional systems and colors as needed.

3.5 INSTALLATION OF DUCT LABELS

- A. Install plastic-laminated or self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.
 - 1. Provide labels in the following color codes:
 - a. For air supply ducts: White letters on blue background
 - b. For air return ducts: White letters on blue background.
 - c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.
 - d. Include additional systems and colors as needed.

END OF SECTION 230553

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
9. Outdoor, concealed supply and return.
10. Outdoor, exposed supply and return.

1.2 ACTION SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DEFINITIONS

A. Supply Air: Air delivered below 60° F or above 80° F.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in the insulation schedule on the plans for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290..
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Owens Corning; SOFTR All-Service Duct Wrap.
- E. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.
- F. ELASTOMERIC INSULATION
 - 1. Acceptable Manufacturers
 - a. These specifications are based on products and data of Armacell and designate the type and quality of work intended under this section. Products of other manufacturers proposed as equivalent must be submitted for written approval by the specifying engineer ten days prior to the bid date. Supporting technical data, samples, published specifications and the like must be submitted for comparison.

The contractor should warrant that proposed substitutions, if accepted, will provide performance equal to the materials specified herein. Insulation material shall be a flexible, closed-cell or conformable, elastomeric insulation in sheet form:

AP Armaflex, AP Armaflex SA, AP Coilflex or AP Spiralflex. These products meet the requirements as defined in ASTM C 534, Grade 1 Type II, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form".

2. AP Armaflex and AP Armaflex SA insulation materials shall have a closed cell structure to prevent moisture from wicking and effectively retard heat gain to make it an efficient insulation. AP Coilflex has a conformable cell structure allowing it to be bent on a coil line brake for tight fit in the corners.
3. Insulation materials shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde-free, low VOCs, fiber free, dust free and resists mold and mildew.
4. The insulation material shall conform to meet the requirements as defined in ASTM C 1534, Standard "Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Adsorbing Liner for Duct Systems".
5. Materials 2" thickness and below, shall have a flame spread index of less than 25 and a smoke developed index of less than 50 when tested in accordance with ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
6. AP Armaflex and AP Armaflex SA materials shall have a maximum thermal conductivity of 0.25 Btu-in/h-ft² - °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
7. AP Armaflex and AP Armaflex SA materials shall have a maximum water vapor transmission of 0.05 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
8. AP Armaflex FS materials shall have a maximum thermal conductivity of 0.28 Btu-in/h-ft² - °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
9. AP Armaflex FS materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
10. Materials shall have a maximum water absorption rate of 0.2% (%by volume), when tested in accordance with ASTM C 209.
11. The material shall be manufactured under an independent third party supervision testing program covering the properties for fire performance, thermal conductivity and water vapor transmission.
12. Materials must be approved for air plenums.
13. Materials must meet NFPA 90A, NFPA 908 and UL 181 Class 1 specification.
14. Materials must meet ASTM C 411. Materials to perform up to 250°F.
15. Pertinent Duct Lining Specification Compliance.
16. ASTM C 1071 - Erosion Resistance.
17. ASTM G 21 - Fungi Resistance.
18. ASTM C 1338 - Fungi Resistance.
19. ASTM G 22 - Bacterial Resistance.
20. ASTM C 665 - Non Corrosiveness and no objectionable odors.

21. NRC rating 0.40 - Test Method ASTM C 423 with ASTM E 795 Type A Mounting. All product except AP Coilflex
22. NRC rating on the AP Coilflex is 0.60 - Test Method ASTM C 423 with ASTM E 795 Type A Mounting.
23. Dust free and fiber free. Non particulating.

2.2 FIBERGLASS DUCT LINER WITH REINFORCED COATING SYSTEM

- A. Equal to Johns Manville Linacoustic RC meeting ASTM C1071 and meeting the following requirements.
 1. "K" ('ksi') value per ASTM C518, 0.24 at 75°F (0.036 at 24°C) based on 1" material thickness.
 2. Noise reduction coefficient of 0.70 minimum when tested in accordance with ASTM C423 when using a type "A" mounting at 1" thickness.
 3. Maximum rated velocity of 6000 FPM (30.5 Meters/Second).
 4. The air stream surface shall have a 100% coverage coating of acrylic polymer formulated with an immobilized EPA registered anti-microbial agent proven resistant to microbial growth as determined by ASTM G21.
 5. Minimum water repellency of 6 on air stream side coating per INDA IST 80.6
 6. Duct liner shall have a FHC of 25/50 and be classified as meeting the requirements of limited combustibility.
 7. Material shall be certified by per GREENGUARD.
 8. Shall not contain asbestos, lead, mercury, or mercury compounds.
- B. Accessories
 1. SuperSeal® and SuperSeal® HV for coating exposed edges, connections or minor surface damage not requiring replacement insulation.
 2. Duct liner adhesive, meeting the requirements of ASTM C916.
 3. Weld pins of sufficient finished length to provide proper compression of insulation.
 4. Metal Channel or "Z" profile for upstream edges of liner.

2.3 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.
 - c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.

- d. Thermal Ceramics; FireMaster Duct Wrap.
- e. 3M; Fire Barrier Wrap Products.
- f. Unifrax Corporation; FyreWrap.

2.4 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Adhesive 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."
- C. ASJ Adhesive, and FSK Jacket Adhesive:
 - 1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.
 - d. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Adhesive 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."

2.5 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers CP-38
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - c. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Solids Content: 60 percent by volume and 66 percent by weight.
 - 5. Color: White.

2.6 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 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 C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide.

1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in

position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, or Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. 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. Comply with the following requirements:
- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO; Nylon Hangers.
 - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
3. 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. Comply with the following requirements:
- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
 - 2) GEMCO; Peel & Press.

- 3) Midwest Fasteners, Inc.; Self Stick.
- b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
- c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, or Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
- d. Adhesive-backed base with a peel-off protective cover.
- 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, or 0.062-inch (1.6-mm) soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 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 (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation,

- install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
- 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
- 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
 - 1. Comply with requirements in other sections for firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:
 - 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
 - 2. Seal penetrations through fire-rated assemblies.

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.

- f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

- c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
- 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. AP Armaflex & AP Armaflex FS Sheet and Rolls

- 1. Armaflex Sheet Insulation shall be adhered directly to clean, oil-free surfaces with a full coverage of Armaflex 520, 520 Black or Low VOC Spray Adhesive. Apply 520, 520 Black and Spray Adhesive to both the Armaflex surface and sheet metal.
- 2. Ambient temperature for applications is between 40 degrees F and 100 degrees F.
- 3. The skin side (smooth side) shall be exposed to the air stream.
- 4. Butt-edge seams shall be adhered using Armaflex 520, or 520 Black Adhesive by the compression fit method to allow for expansion/contraction. Leave a 1/2" wide uncoated border at the butt edge seams on the duct surface and the insulation surface. Overlap the insulation 1/4" at the butt-edges and compress the edges into place. Apply Armaflex 520 or 520 Black. Allow 48 hours for full cure prior to operating system.
- 5. Length of duct should allow for reaching in to apply 100% pressure to all interior surfaces.

6. Refer to Armacell's Installation Booklet for additional installation information.

B. Self Adhering (SA) Armaflex Sheet and Rolls

1. SA Armaflex sheet shall be applied directly to a clean, dry, oil-free surface.
2. Ambient temperature for application must be between 40°F and 100°F.
3. The skin side (smooth side) shall be exposed to the air stream.
4. Install all sheet butt joints with a compression fit. Overlap the insulation 1/4" at the butt-edges and compress the edges into place. Leave 1/2" wide release liner border at the butt edge.
5. Refer to Armacell's Installation Booklet for additional installation information.

- C. Air Velocities above 4,000 FPM (20.3 m/second): Metal nosing should be applied to every leading edge.

- D. AP Coilflex should be applied using an automatic coil line and water based adhesive

- E. AP Spiralflex should be applied to the inside of round duct according to the installation guide written specifically for the AP Spiralflex

3.6 INSTALLATION OF FIBERGLASS DUCT LINER

- A. All portions of duct designated to receive liner shall be completely covered with fiberglass duct liner as specified at the required thickness to provide the indicated R-value. All sections shall be neatly butted together so that there are no interruptions or gaps.
- B. Adhere liner to metal with a full coverage of adhesive meeting ASTM C916.
- C. Secure duct liner with mechanical fasteners in accordance with SMACNA and NAIMA Standards.
- D. Install metal nosing on all leading edges of liner when velocity exceeds 4000 FPM.
- E. SuperSeal will be used to coat all circumferential joints, exposed edges, and minor surface damage after the liner is in place.
- F. SuperSeal HV will be used to fill minor gaps and indentations.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed spaces shall be enclosed from the point of penetration to the outlet terminal.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

- A. Ducts Requiring Insulation:
 1. Indoor, concealed supply and outdoor air.
 2. Indoor, exposed supply and outdoor air.
 3. Indoor, concealed return air in unconditioned space.
 4. Indoor, exposed return air in unconditioned space.

5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
8. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
9. Outdoor, concealed supply, return.
10. Outdoor, exposed supply, return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air (in indirectly conditioned, plenum spaces) duct insulation:

1. No insulation required.

C. Concealed, round and flat-oval, outdoor-air (unconditioned) duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation between the building exterior and the backdraft damper shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Concealed, rectangular, return-air duct (return boots only), and all transfer ducts insulation shall be the following:

1. Mineral-Fiber Blanket: 1/2 inch fiberglass duct liner with reinforced coating system

- G. Concealed, rectangular, return-air (in unconditioned space) duct insulation shall be the following:
1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- H. Concealed, rectangular, outdoor-air (unconditioned) duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- I. Concealed, rectangular, exhaust-air duct insulation between the building exterior and the backdraft damper shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- J. Exposed, round and flat-oval, supply-air duct insulation shall be the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
 2. Normally occupied areas, within 30 ft of air moving equipment (fan coils, DOAS, etc.): 1" fiberglass duct liner with reinforced coating system.
 3. Normally occupied areas, beyond 30 ft of air moving equipment: Flexible Elastomeric Lining: 3/4 inch.
- K. Exposed, round and flat-oval, return-air duct insulation:
1. No insulation required
- L. Exposed, round and flat-oval, return-air (in unconditioned space) duct insulation:
1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- M. Exposed, round and flat-oval, outdoor-air (unconditioned) duct insulation shall be the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Lining: 3/4 inch.
- N. Exposed, round and flat-oval, exhaust-air duct insulation between the building exterior and the backdraft damper shall be one of the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Lining: 3/4 inch.
- O. Exposed, rectangular, supply-air duct insulation shall be one of the following:

1. Back of house and not normally occupied areas storage rooms, etc.): Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
 2. Normally occupied areas, within 30 ft of air moving equipment (fan coils, DOAS, etc.): 1" fiberglass duct liner with reinforced coating system.
 3. Normally occupied areas, beyond 30 ft of air moving equipment: Flexible Elastomeric Lining: 3/4 inch.
- P. Exposed, rectangular, return-air duct insulation:
1. No insulation required.
- Q. Exposed, rectangular, return-air (in unconditioned space) duct insulation:
1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- R. Exposed, rectangular, outdoor-air (unconditioned) duct insulation shall be the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Liner: 3/4 inch.
- S. Exposed, rectangular, exhaust-air duct insulation between the building exterior and the backdraft damper shall be one of the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Liner: 3/4 inch.
- T. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket; thickness as required to achieve 2-hour fire rating. Grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed spaces shall be enclosed from the point of penetration to the outlet terminal.
- 3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE
- A. For above ground outdoor duct, utilize the non-fibrous, closed cell, outdoor ductwork specified in section 233115.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Chillers.
2. Chilled-water pumps.
3. Expansion/compression tanks.
4. Air separators.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 232113.13 "Underground Hydronic Piping"

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- C. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide.
- D. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
- E. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Armacell LLC; AP Armaflex or AP Armaflex FS or a comparable product by one of the following:
 - a. Aeroflex USA, Inc.
 - b. K-Flex USA.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Armacell LLC; Armaflex 520 Adhesive or a comparable product by one of the following:

- a. Aeroflex USA, Inc.
- b. Foster Brand; H. B. Fuller Construction Products.
- c. K-Flex USA.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive 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."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
4. Color: White or gray.

5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Sheet and roll stock ready for shop or field sizing.
 2. Finish and thickness are indicated in field-applied jacket schedules.

3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
5. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Width: 3 inches (75 mm).
 2. Thickness: 11.5 mils (0.29 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Width: 3 inches (75 mm).
 2. Thickness: 6.5 mils (0.16 mm).
 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 6. 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. Width: 2 inches (50 mm).
 2. Thickness: 6 mils (0.15 mm).
 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches (75 mm).
2. Film Thickness: 4 mils (0.10 mm).
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. 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 (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. 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 (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy.

2.10 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. 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. Manholes.
 5. Handholes.
 6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

- A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

- a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches (75 mm).
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum, at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

C. Flexible Elastomeric Insulation Installation for Pumps:

1. Follow manufacturer's written instructions.

3.4 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.6 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.

3.7 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.

- C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- D. Chilled-water pump insulation shall be the following:
 - 1. Flexible Elastomeric: 2 inches thick.
- E. Chilled-water expansion/compression tank insulation shall be the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- F. Chilled-water air-separator insulation shall be the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- G. Condenser-water air-separator insulation shall be the following:
 - 1. Flexible Elastomeric: 1 inch thick.

3.8 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 - 1. Aluminum, Stucco Embossed: 0.020 inch thick.
- D. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
 - 1. Aluminum, Stucco Embossed: 0.032 inch thick.

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors
2. Chilled-water piping.
3. Refrigerant suction and hot-gas piping.

- B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."
3. Section 232113.13 "Underground Hydronic Piping"

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- B. Products located in return air plenums shall be noncombustible with a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- G. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aeroseal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
 - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Adhesive 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."
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive 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."
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive 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. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive 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."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.

- d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
- 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 3. Permanently flexible, elastomeric sealant.
 - 4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - 5. Color: White or gray.
 - 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
- 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 5. Color: Aluminum.
- 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
- 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 5. Color: White.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, 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 D 1784, 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: To be determined in consultation with the architect.
 4. 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.

- D. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Sheet and roll stock ready for shop or field sizing.
 3. Finish and thickness are indicated in field-applied jacket schedules.
 4. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 5. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, or 0.062-inch (1.6-mm) soft-annealed, galvanized steel.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. If applicable, coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar 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. Manholes.
 5. Handholes.
 6. Cleanouts.

3.3 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 (50 mm) 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 (50 mm).
 - 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 other sections 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.

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe

- insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform 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 adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two 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 (50 mm) 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.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. 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.
- C. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. 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 shall be limited to three locations of straight pipe, three locations of fittings and three locations of specialties such as valves, etc.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable insulation and jacket materials are identified above. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate Drains:
1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

B. Chilled Water, above 40 Deg F:

1. NPS 1-1/4" and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1/2 inch thick.
2. NPS 1-1/2" and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

C. Cold Refrigerant Suction Piping Only:

1. NPS 1-1/4" and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1/2 inch thick.
2. NPS 1-1/2" and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water, above 40 Deg F:

1. NPS 1-1/4" and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
2. NPS 1-1/2" and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 2 inch thick.

B. Cold Refrigerant Suction Piping Only:

1. NPS 1-1/4" and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1/2 inch thick.
2. NPS 1-1/2" and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

3.12 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. All Piping, Exposed:
 - 1. PVC: 30 mils (0.8 mm) thick.

3.13 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.
- C. Piping, Exposed:
 - 1. Aluminum, Smooth 0.024 inch thick.

END OF SECTION 230719

SECTION 230800 – COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:

1. Energy supply systems.
2. Cooling generation systems.
3. Central-station air-handling systems.
4. Air, steam, and hydronic distribution systems.
5. Heating and cooling terminal and unitary equipment.
6. HVAC controls.
7. TAB verification.
8. Domestic Water System
9. Potable water system and filtration
10. Building Envelope Roof, Roof Exterior walls and Floors
11. Solar Energy Systems

- B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. Section 230995 - Trending, Remote Monitoring, and Data Analytics for monitoring in Cx process requirements.
3. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products and ASHRAE Guideline 1.1-2007 "HVAC&R Technical Requirements for the Commissioning Process", ASHRAE Guideline 0-2013 "The Commissioning Process"

C. DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. IgCC: International Green Construction Code.

- 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.
- F. TAB: Testing, adjusting, and balancing.

1. INFORMATIONAL SUBMITTALS

Qualification Data: For **BAS and HVAC** testing technician.

B. Construction Checklists:

- 1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.

C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Div. 23 Subcontractor, 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. BAS Testing Technician Qualifications: Technicians performing BAS Cx test demonstrations are to have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
 - 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
 - 3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.

- B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
 - 2. Minimum **three years'** experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.
- C. 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.
- D. 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS:

- A. Perform Cx process in accordance with Section ASHRAE Commissioning Requirements" for BAS, HVAV, Plumbing, Building Components, and Solar Energy Systems in accordance with the following:
 - 1. ASHRAE Guideline 1.1-2007 "HVAC&R Technical Requirements for the Commissioning Process", AHSRAE Guideline 0-2013 "The Commissioning Process" and ASHRAE 202.

3.2 CONSTRUCTION CHECKLISTS

- A. Preliminary detailed construction checklists are to be prepared under Section 019113 "General COMMISSIONING OF HVAC

Commissioning Requirements" for each BAS, HVAC, Plumbing, Building Components, and Solar Energy Systems, assembly, subsystem, equipment, and component required to be commissioned, as detailed in ASHRAE 202. Contractor performs the following:

1. Review BAS, HVAC, Plumbing, Building Components, and Solar Energy Systems preliminary construction checklists and provide written comments on checklist items where appropriate.
 2. Return preliminary Construction Checklist with review comments
 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)" When performing tests. 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 BAS, HVAC, Plumbing, Building Components, and Solar Energy Systems 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)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed and provide pertinent details and other information.
- C. Systems required to be commissioned and integration into the local BAS system and the System Wide Enterprise system.
1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and/or passive) and associated controls.
 2. Air-curtain systems.
 3. Water-pumping and -mixing systems over 5 hp (4 kW) and purification systems.
 4. Renewable energy systems and energy storage systems.
 5. Energy and building management and demand-control systems.
- D. Additional systems required to be commissioned:
1. Energy supply systems, including the following:
 - a. Fuel-oil supply.
 - b. Fuel gas supply.
 - c. Solar-energy supply.
 - d. Renewable energy systems.
 - e. Energy storage systems.
 - f. Demand-control systems.
 2. Cooling generation systems, including the following:
 - a. Water chillers.

- b. Direct-expansion refrigeration systems.
- 3. Air-handling systems, including the following:
 - a. Supply, return, and exhaust air fans, motors, and drives.
 - b. Automatic and gravity dampers.
 - c. Heating and cooling devices.
 - d. Humidification and dehumidification devices.
 - e. Air filters.
 - f. Hangers and supports.
 - g. Interlock between air-handling system and fire/smoke alarm system.
- 4. Air duct systems, including the following:
 - a. Duct systems.
 - b. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
 - c. Duct-mounted access doors and panels.
 - d. Hangers and supports.
 - e. Sound Attenuation
- 5. Air curtain systems.
 - a. Supply air fans and motors.
- 6. Hydronic distribution systems, including the following:
 - a. Hydronic piping systems and all accessories.
 - b. Pumps and all accessories.
 - c. Sleeves and sleeve seals.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports
- 7. Refrigerant piping, including the following:
 - a. Refrigerant piping, fittings, and specialties.
 - b. Refrigerant charge.
 - c. Sleeves and sleeve seals.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
- 8. Cooling terminal and unitary equipment, including the following:
 - a. Unit ventilators.
 - b. Fan-coil units.
 - c. Unitary cooling equipment.
 - d. Heat Pipes
- 9. Vibration isolation systems.

10. Controls and instrumentation, including the following:
 - a. Energy monitoring and recording system.
 - b. Controllers and sensors.
 - c. Automatic control valves, dampers, and actuators.
 - d. Control interface with fans, pumps, dampers, and other equipment and systems.
 - e. Demand-control systems.
11. Plumbing System
 - a. Cistern
 - b. Water Distribution Pumps
 - c. Water Cartridge Filter
 - d. Water Carbon filter
 - e. Water Reverse Osmosis Filter
 - f. Water UV filter
12. Building Components
 - a. Roof
 - b. Exterior Walls
 - c. Floors
 - d. Windows
 - e. Vapor Barriers
13. TAB Verification:
 - a. Airflow.
 - b. Water flow.
 - c. Space pressurization.
14. Documentation:
 - a. Mechanical systems manuals.
 - b. Documentation of required commissioning.
15. Mechanical insulation, including the following:
 - a. Duct and plenum insulation.
 - b. HVAC piping insulation.

3.3 Cx TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been Designed according to the owners requirement and commissioning plan (Formal review at design development, 50% construction documents, and Permit Documents), installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that HVAC 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 all systems are set to and maintaining set points as required by the design documents.

- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., 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 Owner, 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 HVAC system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- C. Seasonal test complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 Cx TESTS COMMON FOR ALL COMMISSIONED 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 in accordance with 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 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:

1. Cx Construction Checklist verification tests.

- F. Verify integration into the local BAS system and the System Wide Enterprise system

3.6 CONSTRUCTION CHECKLIST EXAMPLES

A. Vibration Isolation in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for vibration and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" Section 230548.13 "Vibration Controls for HVAC Piping and Equipment".
2. Components to Be Tested:
 - a. Vibration isolation control devices in HVAC systems.
 - b. Support systems.
3. Test Purpose: Evaluate effectiveness of vibration isolation control devices.
4. Test Conditions, Variable Speed Equipment: Measure vibration of the facility structure at three locations designated by Owner's witness at the following operating conditions:
 - a. Maximum speed.
 - b. Minimum speed.
 - c. Critical speed.
5. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

3.7 TAB VERIFICATION

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
- C. Scope: HVAC air systems and hydronic piping systems.
- D. Purpose: Differential flow relationships intended to maintain air and water pressurization differentials between the various areas of Project.
- E. Conditions of the Test:
 1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
 2. Systems operating in full cooling mode.

3. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

F. Acceptance Criteria:

1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.8 CHILLER SYSTEM Cx TESTS

A. Start-and-Stop Condenser-Water Pump(s):

1. Prerequisites: Installation verification of the following:
 - a. Startup of condenser-water pump(s)
 - b. Input Device: Water pressure transducer
 - c. Input Device: DDC system outdoor-air temperature
 - d. Input Device: DDC system time schedule
 - e. Output Device: Hard wired through motor starter; DDC system binary output
 - f. Display the following at the operator's workstation:
 - 1) Low-level cooling-tower sump alarm.
 - 2) Outdoor-air temperature.
 - 3) Cooling (software) demand indication.
 - 4) Time and time schedule.
2. Conditions of the Test:
 - a. Verify Lockout: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state, and then return each to the "disable" state before placing the next enable-input device to the "enable" state.
 - b. Verify Start: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state.
 - c. Verify Shutdown: Place all enable-input devices in the "enable" state to allow the pump(s) to start. One by one, place the enable-input devices in the "disable" state, and then return each to the "enable" state before placing the next enable-input device to the "disable" state.
 - d. Verify Schedule: Compare condenser-water pump start-and-stop schedule times with Owner-approved time-of-day schedule.

3. Acceptance Criteria:

- a. Lockout: No single enable-input device starts the pump(s) when released to the "enable" state.
- b. Start: Condenser-water pump(s) start when, and only when, all enable-input devices are in the "enable" state.
- c. Shutdown: Each enable-input device stops the condenser-water pump(s) when placed in the "disable" state, regardless of the state of other enable-input devices.
- d. Schedule: Condenser-water pump start-and-stop schedule times agree with Owner-approved time-of-day schedule.

B. Start-and-Stop Chilled-Water Pump(s):

- 1. Prerequisites: Installation verification of the following:
 - a. Startup of chilled-water pump(s)
 - b. Startup of cooling tower
 - c. Input Device: Flow switch in condenser-water circuit
 - d. Output Device: DDC system command to starter relay.
 - e. Display one of the following at the operator's workstation:
 - 1) Chilled-water flow indication.
 - 2) Condenser-water flow indication.
 - 3) Chilled-water pump(s) on-off status.
 - 4) Chilled-water pump(s) on-off indication.
- 2. Scope: Chilled-water system, including chilled-water pump(s), associated controls, and condenser-water system controls.
- 3. Purpose:
 - a. Chilled-water pump(s) start.
 - b. Chilled-water pump(s) shutdown.
- 4. Conditions of the Test:
 - a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
 - b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device in the "disable" state.
- 5. Acceptance Criteria:
 - a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
 - b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

C. Alternative Chiller(s):

- 1. Prerequisites: Installation verification of the following:

- a. Input Device: DDC system software
 - b. Output Device: DDC system command to chiller terminal strip.
 - c. Display:
 - 1) Chiller(s) on-off indication.
 - 2) Chiller failure alarm.
2. Scope:
 - a. Chilled-water system and associated controls.
 - b. Condenser-water system and associated controls.
3. Purpose:
 - a. Lead-lag rotation of chillers.
 - b. Replacement of failed chiller in rotation.
 - c. Adding and dropping chillers as follows: <Insert sequence and parameters>.
 - d. Replacement of failed chiller in add/drop sequence.
 - e. Chiller failure alarm initiation.
4. Conditions of the Test:
 - a. Lead-Lag Rotation - Chiller Start: Create a number of chilled-water system start-stop cycles equal to the number of chillers plus one.
 - b. Lead-Lag Rotation - Lead Chiller Fail: Disable the lead chiller while it is running.
 - c. Lead-Lag Rotation - Lag Chiller Fail: Disable a lag chiller while it is running.
 - d. Lead-Lag Rotation - Chiller Start Fail: Disable a chiller while it is in standby mode. Initiate a lead-lag rotation call for the disabled chiller to start.
 - e. Add/Drop Sequence - Increasing Demand: Increase chilled-water demand incrementally to observe the corresponding addition of chillers. Increase demand gradually as the load approaches the set point for adding the next chiller, to permit observation of the actual load at the time the next chiller is enabled.
 - f. Add/Drop Sequence - Decreasing Demand: Decrease chilled-water demand incrementally to observe the corresponding dropping of chillers. Decrease demand gradually as the load approaches the set point for dropping the next chiller, to permit observation of the actual load at the time the next chiller is disabled.
5. Acceptance Criteria:
 - a. Lead-Lag Rotation - Chiller Start: On each chilled-water system start event, the next chiller in rotation starts as the lead chiller, and the previous lead chiller, is designated as the last-lag chiller.
 - b. Lead-Lag Rotation - Lead Chiller Fail: When the lead chiller fails, the next chiller in rotation starts as the lead chiller, and a chiller failure alarm, is initiated for the failed chiller.
 - c. Lead-Lag Rotation - Lag Chiller Fail: When the lag chiller fails, the next chiller in rotation starts as the lead chiller, and a chiller failure alarm is initiated for the failed chiller.
 - d. Lead-Lag Rotation - Chiller Start Fail: When a chiller fails to start, the next chiller

in rotation starts in its place, and a chiller failure alarm is initiated for the failed chiller.

- e. Add/Drop Sequence - Increasing Demand: Chillers are added at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus 2.0 deg F 1.1 deg C) of set point.
- f. Add/Drop Sequence - Decreasing Demand: Chillers are dropped at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus of set point.
- g. Add/Drop Sequence - Operating Chiller Fail: When an operating chiller fails, the next chiller in sequence starts and a chiller failure alarm is initiated for the failed chiller.
- h. Add/Drop Sequence - Chiller Start Fail: When a chiller fails to start, the next chiller in sequence starts in its place and a chiller failure alarm is initiated for the failed chiller.

3.9 TERMINAL UNIT EQUIPMENT Cx TESTS

A. VAV Terminal Air Units with Coils:

- 1. Prerequisites: Installation verification of the following:
 - a. Occupancy Input Device: Occupancy sensor.
 - b. Occupancy Output Device: DDC system binary output.
 - c. Room Temperature Input Device: Electronic temperature sensor.
 - d. Room Temperature Output Device: Electronic damper actuators and control-valve operators.
 - e. Display the following at the operator's workstation:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Air-damper position as percentage open.
 - 8) Control-valve position as percentage open.
- 2. Scope: VAV terminal air units] coils and associated controls.
- 3. Purpose:
 - a. Occupancy-dependent room temperature set-point reset.
 - b. Room temperature control.
- 4. Conditions of the Test:
 - a. Cx Test Demonstration Sampling Rate: [0 percent of each model/size unit.
 - b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until

- c. room temperature is stable at occupied set point, plus or minus 1.0 deg F
 - c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point, plus or minus 1.0 deg
- 5. Acceptance Criteria:
 - a. Temperature Control - Occupied:
 - 1) Control system status changes from "occupied" to "unoccupied" after the specified time.
 - 2) Room temperature is stable at occupied set point, plus or minus 1.0 deg F within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than [2.0 deg F (1.1 deg C)] during transition.
 - b. Temperature Control - Unoccupied:
 - 1) Control system status changes from "unoccupied" to "occupied" after five minutes of continuous occupancy.
 - 2) Room temperature is stable at unoccupied set point, plus or minus 1.0 deg within 30 minutes of occupancy.

3.10 AIR-HANDLING SYSTEM Cx TESTS

A. Supply Fan(s) Variable-Volume Control:

- 1. Prerequisites: Installation verification of the following:
 - a. Volume-Control Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to conditioned-space static pressure.
 - b. Volume-Control Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
 - c. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
 - d. High-Pressure Output Device: DDC system binary output to alarm panel
 - e. Display the following at the operator's workstation:
 - 1) Supply-fan-discharge static-pressure indication.
 - 2) Supply-fan-discharge static-pressure set point.
 - 3) Supply-fan airflow rate.
 - 4) Supply-fan speed.
- 2. Scope: VAV supply fan units and associated controls.
- 3. Purpose:
 - a. Supply-air discharge static pressure control.
 - b. Response to excess supply-air discharge static pressure condition.
- 4. Conditions of the Test:

- a. Minimum supply-air flow.
 - b. Midrange Supply-Air Flow: 50 to 60 percent of maximum.
 - c. Maximum supply-air flow.
 - d. Excess supply-air discharge static pressure.
5. Acceptance Criteria:
- a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
 - b. Fan stops and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure, plus or minus 2 > percent.
- B. Air-Handler Cooling Coil Discharge and unit Discharge air -Air Control:
1. Prerequisites: Installation verification of the following:
- a. Minimum Position Input Device: DDC system time schedule.
 - b. Output Device: DDC system analog output] to modulating damper actuator(s).
 - c. Mixed-Air Temperature Input Device: Electronic temperature sensor.
 - d. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.
 - e. Display the following at the operator's workstation:
 - 1) Mixed-air-temperature indication.
 - 2) Mixed-air-temperature set point.
 - 3) Mixed-air damper position.
 - 4) Cooling Coil leaving condition
 - 5) Heat pipe entering and leaving condition
 - 6) Unit discharge air temperature
2. Scope: Air handler with mixed-air control and associated controls.
3. Purpose:
- a. Occupied time control.
 - b. Minimum damper position control.
 - c. Supply air temperature control.
 - d. Cooling coil control.
 - e. Unoccupied time control.
4. Conditions of the Test:
- a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
 - b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
 - c. Heating Reset Control: Create a call for heating.
 - d. Supply Air Temperature Control: Override supply air temperature set point to a value 2.0 deg F above current supply air temperature.
 - e. Unoccupied Time Control: Advance to unoccupied schedule time.

- f. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at hourly recording frequency > intervals. Submit trend data for 24-hour periods in which natural conditions require heating reset control, supply air temperature control, and cooling reset control.
 - 1) Minimum position input device.
 - 2) Heating reset input device.
 - 3) Supply air temperature input device.
 - 4) Cooling reset input device.
- 5. Acceptance Criteria:
 - a. Occupied Time Control: Mixed-air control is active in occupied mode.
 - b. Minimum Damper Position Control:
 - c. Supply, Cooling Coil leaving, heat pipe entering and leaving Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary supply air temperature set point, plus or minus 1.0 deg F.
 - d. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
 - e. Control Data Trend Log: Data verify control in accordance with sequence of control.
- C. Potable Water System
 - 1. Verify through independent lab that the potable water system, with feeds from the local utility and when feed from the site-specific cistern comply with the US Department of Health Potable Water standard and specification.
 - 2. Veracity integration into the local BAS system and the System Wide Enterprise system
- D. Solar Energy Recovery System
 - 1. Verify the design, installation and operational characteristics and integration into the local BAS system and the System Wide Enterprise system meet the owners project's requirements.
- E. Building Components
 - 1. Verify the design, installation and operational characteristics and integration into the local BAS system and the System Wide Enterprise system, meet the owners project's requirements for: Roofs, Exterior walls, vapor barrier, insulation, and floors on grade or suspended above open air spaces.

END OF SECTION 230800

SECTION 230923.01 - ENTERPRISE DIRECT DIGITAL CONTROL AND CAMPUS BUILDING
AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 GENERAL

- A. Provide an Enterprise Operator Interface System with the required building controllers to integrate, monitor and control mechanical, electrical, plumbing and fire sprinkler systems equipment associated with all school renovation and replacement projects.
- B. The Enterprise operator interface shall be a web-based, systems integration solution that provides the Virgin Island Department of Education an online, enterprise-wide, system wide, view and control over of all their buildings and systems, from any device with a web browser on the network. (PC, laptop, tablet, smart phone).
- C. The system shall collect and display data from other systems via BACnet™ IP, providing users the critical information needed to make enterprise-wide decisions for optimized performance
- D. The Enterprise operator web interface shall be accessible via a web browser without requiring any “plug-ins” (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
- E. The Enterprise system shall be capable of supporting a minimum of 35 campuses with multiple buildings each.
- F. The Enterprise system shall be capable of expansion to support up to an additional 35 campuses with multiple buildings without major software upgrades or additions for the first 5 years of system operation.
- G. The Enterprise operator interface software can be installed on a local server provided by the building owner. The server hardware and any System level controllers are to reside on the building owner’s network. (Note: The central server hardware, associated server operating system software, network cabling and switches is to be provided by others).
- H. The Enterprise system shall be capable of resetting all system programs, set points, and schedules to the system setting present at acceptance of the system by the owner and as modified by the technicians with highest level of access. The reset shall be schedulable from twice a week to once every two weeks.
- I. As an option, The Enterprise operator interface software shall be provided as a cloud-based service, the manufacture shall include a five-year cloud base service as part of this contract.
- J. As an option, the Enterprise system shall be capable of incorporating a fully functional Computer Maintenance Management System, CMMS to support school defined in items E and F above.

K. WARRANTY

1. Provide a full parts and labor warranty for two year from project substantial completion acceptance by owner, whichever occurs first.
2. Provide a full parts warranty for five year from project substantial completion acceptance by owner, whichever occurs first.
3. Contractor to certify and provide warranty service within 4 hours to each site by factory trained personnel once informed by the owner of a problem.
4. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

PART 2 - PRODUCTS

2.1 ENTERPRISE SYSTEM - APPROVED MANUFACTURERS

A. Approved Manufacturers

1. Trane Tracer® – Basis of Design
2. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid.

B. SUBMITTALS

1. Submit dimensional plan and elevation view drawings, weights and loadings, required clearances, location and size of all field connections, electrical requirements and wiring diagrams.
2. Submit product data indicating rated capacities, accessories and any special data.
3. Submit manufacturer's installation instructions.

C. Provide 5 extra controllers, sensors, motor operators and control devices for each type of device used for owner to use as stock for maintenance and replacement.

2.2 ENTERPRISE SYSTEM - OPERATOR WEB INTERFACE

A. Building / Campus Health Operator Interface View

1. The Enterprise operator interface shall provide a standard building health view that provides visual indication of which buildings have issues
2. The Enterprise operator interface building health will display the summary information including number of active alarms for today, number of devices off-line, number or

hot/cold spaces, cistern low level alarms, electrical system alarms, emergency electrical system alarm, solar power system alarms and fire sprinkler system alarms.

3. The Enterprise operator interface shall provide a direct link from any building health card to a building summary view that displays: active alarms for today, current chiller plant stats (if applicable), air handler status, spaces that are too hot/cold, cistern low level alarms, potable water system alarms, electrical system alarms, emergency electrical system alarms, solar power system alarms and fire sprinkler system alarms. .
4. The Enterprise operator interface shall provide the ability to group, filter, and sort the list of buildings
5. The Enterprise operator interface shall allow a user to save filtering and grouping options as their default view
6. The Enterprise operator web interface shall allow a user to disable the building health display for any building.

B. Customizable Navigation Tree

1. The Enterprise operator web interface shall include a fully customizable navigation tree that shall allow an operator to do the following:
 - a. Move and edit any of the nodes of the tree.
 - b. Move entire groups to any area of the tree
 - c. Change the name of any node in the tree
 - d. Create custom nodes for any page in the web interface including: graphics, data log views, schedules, and dashboards
 - e. Support navigation from multi-building to single building view
 - f. Provide the ability to assign graphics to any node in the tree
 - g. Ability to create folders and assign and change hierarchy of nodes of the tree

C. Provide Mobile App Interface

1. The Enterprise operator interface shall have support multi-tier password, with each tier assignable. Each higher-level tier shall have rights to modify system with the lower levels only able to view and the highest level able to modify individual device at any location.
2. Enterprise Operator Interface manufacturer shall provide a phone/tablet interface with the ability to view/override status & setpoints, view/change schedules, view/acknowledge/comment on alarms, and view graphics for all spaces and equipment.
3. This phone/tablet interface shall resize itself appropriately for the size of the interface (i.e. no "pinching & zooming" required). This phone/tablet interface shall function remotely from the facility while following IT security best-practices (e.g. no ports exposed to the internet).
4. Provide mobile (smart phone or tablet) interfaces to the building automation system, compatible with iOS and Android™ operating systems.
5. Controls manufacturer shall provide a phone/tablet interface with the ability to view/override status & setpoints, view/change schedules, view/acknowledge/comment on alarms, and view graphics for all spaces and equipment.

6. This phone/tablet interface shall resize itself appropriately for the size of the interface (i.e. no "pinching & zooming" required).
7. This phone/tablet interface shall function remotely from the facility while following IT security best-practices (e.g. no ports exposed to the internet).
8. The operator interface shall support system access on a mobile device via a mobile app to:
 - a. Alarm log
 - b. System Status
 - c. Equipment status
 - d. Space Status
 - e. Standard Equipment graphics
 - f. Override set points
 - g. Override occupancy
 - h. Acknowledge Alarms
 - i. Comment on Alarms

D. Equipment & Application Pages

1. The Enterprise operator web interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - a. Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:
 - 1) Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower, cistern, potable water system and all components, fire sprinkler system including pumps and devices, electrical normal power systems, electrical backup power systems, electrical sustainable power systems, information technology systems, and security systems. These graphics shall show all points dynamically as specified in the points list.
 - 2) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other pages.
 - b. Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
 - c. Historical Data (As defined in Data Log section below) for the equipment or application without requiring a user to navigate to a Data Log page and perform a filter.
 - d. View of all custom graphical programming for supported controllers in real time
 - e. View and management of all points for equipment and applications
 - f. Support documents that have been assigned for that equipment
 - g. Live data view for any selected points
 - h. Touch friendly design for all action buttons, navigation, and spacing

E. System Graphics.

1. Enterprise operator interface shall be graphically based and shall include at least one graphic per piece of equipment as previously indicated, or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
2. Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
3. Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
4. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

F. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.

G. Custom Graphics library. Furnish a custom graphics library of all nonstandard equipment such as electrical equipment, plumbing equipment, fire sprinkler equipment and user defined equipment.

H. Document Support. The Enterprise operator web interface shall support the ability to import support files into a support files library.

1. Imported support files can include the following types of document formats: pdf, docx, xlsx, pptx, jpeg, tif, bmp, png, jpg, gif
2. All imported support files can be associated directly with equipment or family types that can then be accessed directly from standard pages

I. Manual Control and Override.

1. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system.
2. Timed Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
3. Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
4. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
5. Global Point Control. Provide a method for a user to view, override, and edit if applicable, the status of multiple object and properties in the system. The point status shall be available by menu, on graphics or through custom programs.

6. Creating Override Search Queries. The system shall allow the operator to search for overrides across building(s), equipment, systems. User shall have the ability to view and release multiple overrides at once or one at a time.
 7. The Enterprise system shall be capable of resetting all system programs, set points, and schedules to the system setting present at acceptance of the system by the owner and as modified by the technicians with highest level of access. The reset shall be schedulable from twice a week to once every two weeks.
- J. Scheduling. A user shall be able to perform the following tasks utilizing the Enterprise operator web interface:
1. Create a new schedule, defining the default values, events and membership.
 2. Create exceptions to a schedule for any given day.
 3. Apply an exception that spans a single day or multiple days.
 4. View a schedule by day, week and month.
 5. Exception schedules and holidays shall be shown clearly on the calendar
 6. Modify the schedule events, members and exceptions.
 7. Create schedules and exceptions for multiple buildings
 8. Apply emergency schedule to multiple buildings
 9. Drag and drop scheduling editing
 10. Global schedule and exceptions across multiple buildings
- K. Data Logs
1. The Enterprise operator web interface shall allow a user with the appropriate security permissions to define a Data Log for any data in the system.
 2. The Enterprise operator web interface shall allow a user to define any Data Log options as described in the Application and Control Software section.
 3. The operator shall be able to specify the duration of historical data to view by scrolling, zooming, or selecting from a pull down list.
 4. The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
 5. Operator will have the ability to show alarms and overrides on any data log view.
 6. The Enterprise operator web interface shall allow a user to Print or download Data Log views in multiple formats including raw data (CSV, XLS) or image (PNG, JPG, PDF, SVG).
- L. Alarm/Event Notification
1. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
 2. The operator will have the option of selecting an audible alarm notification for all alarm classes they subscribe to.
 3. The system operator will have the option of setting specific times and days that that they will receive alarm notifications.

4. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any Enterprise operator interface.
 - a. The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 24 categories based on severity.
 - b. Alarm/event messages shall use full language, easily recognized descriptors.
 - c. An operator with the proper security level may acknowledge and clear alarms/events.
 - d. All alarms/events that have not been cleared by the operator shall be stored by the building controller.
 - e. The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
 - f. All alarm logs will provide both grouping multiple filter options for sorting and locating specific alarm or groups of alarms.
 - g. Alarm logs shall provide the ability to navigate directly to object with one click
5. Alarm Configuration.
 - a. The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
 - b. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
 - c. The operator shall be able to set up conditional alarm limits based on reference points.
 - d. The operator shall be able to create queries to see current alarm properties across building(s), equipment, systems for any available point.
 - e. The operator shall be able to run saved queries to see current alarm settings and modify and change them in mass.
- M. User Change Log. The operator shall be able to view all logged user changes in the system from any Enterprise operator interface.
 1. An operator shall be able to group user changes by: date, affected, date & affected, user, date & user, transaction type, date & transaction type, or sort only.
 2. The operator will have the option of additional filtering capability of: date, transaction, type, user, affected, and details that can be used individually or in conjunction with other filters.
- N. Standard and Custom Reports
 1. The Enterprise operator web interface shall provide a reporting package that allows the operator to select reports to run.
 2. The Enterprise operator web interface shall provide the ability to schedule reports to run at specified intervals of time.
 3. The Enterprise operator web interface shall provide the ability to email schedule reports at specified intervals of time.

4. The Enterprise operator web interface shall allow a user to create reports in either a pdf. or Excel format.
5. Reports and logs shall be readily printed to the system printer.
6. The Enterprise operator web interface shall provide the ability to create and modify both standard and custom reports.
7. The following standard reports shall be available without requiring a user to manually design the report:
 - a. All Points in Alarm Report: Provide an on-demand report showing all current alarms.
 - b. All Points in Override Report: Provide an on-demand report showing all overrides in effect.
 - c. Site Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - d. Air Handler Status Report: Current status and short historical operation of selected air handlers
 - e. Air System Status Report: Current status and short historical operation of selected VAS
 - f. Area Status Report: Current status and short historical operation of selected Area
 - g. Chiller Plant Status Report: Current status and short historical operation of selected chiller plant
 - h. Chiller Status (ASHRAE) Report: Standard points defined by ASHRAE 147-2013 for tracking and operation of air conditioning equipment
 - i. Schedules Report: List of all weekly events for all schedules in selected buildings
 - j. Space Comfort Analysis Report: List of spaces that meet selected criteria for potential comfort issues (temp variance, high, low, unoccupied)
 - k. Space List Report: Current status of multiple spaces in selected buildings
 - l. Space Status Report: Current status and short historical operation of selected spaces
 - m. Electrical campus usage report.
 - n. Electrical backup system status and events report.
 - o. Electrical sustainable system status and events report.
 - p. Fire sprinkler pump and system status and events report.
 - q. Plumbing system status and events reports.
8. The following custom report functionality shall be available without requiring a third-party reporting tool:
 - a. Bar Chart: Create a bar chart for any data log or custom report equation in the system
 - b. Line Chart: Create a line chart for any data log or custom report equation in the system
 - c. Scatter Plot: Create a scatter plot for any data log or custom report equation in the system
 - d. Histogram: Create a Histogram for any data log, point, or custom report equation in the system

- e. Pie Chart: Create a Pie chart for any data log, point, or custom report equation in the system
- f. Single Values: Display single values from any point, data log, or equation on a custom report
- g. Values Table: Display a formatted table for point values from any family type (spaces, air handlers, chillers, areas, air systems, chiller plants, or programmable controllers)
- h. Data Log Table: Create a formatted table from selected data logs
- i. User Change Log Table: Create a formatted table of user changes with date/time, user, what was changed, new/old value for any family type (spaces, air handlers, chillers, areas, air systems, chiller plants, or programmable controllers)
- j. Text Box: Create a text boxes that can be placed and sized on any custom report
- k. Image: Download and place images that can be placed and sized on any custom report
- l. Size and position of ability of all items on a custom report
- m. Both standard and custom page size capabilities
- n. Save, edit, delete, and save as capability
- o. Equation capability on data logs or points that can be used in custom reports (+, -, *, /)

O. Customization Dashboards

- 1. The Enterprise operator interface shall provide a dashboard package that allows the operator to select dashboards to view, select as their home page or add to their navigation tree.
- 2. Dashboards will be responsive to all screen size and work with any size monitors, tablets, or smart phones
- 3. The Enterprise operator web interface shall provide the ability to create and modify dashboards without the use of any 3rd party tools.
- 4. The following dashboard functionality shall be available without requiring a third-party reporting tool:
 - a. Bar Chart: Create a bar chart for any data log/trend in the system
 - b. Line Chart: Create a line chart for any data log/trend in the system
 - c. Histogram: Create a Histogram for any data log/trend, point in the system
 - d. html web page: ability to display webpages directly in dashboard
 - e. Status Values: Display single or multiple values from any point, data log, in the system
 - f. Values Table: Display a formatted table for point values from any family type (spaces, air handlers, chillers, areas, air systems, chiller plants, or programmable controllers)
 - g. Text Box: Create a text boxes that can be placed and sized on any dashboard
 - h. Image: Download and place images that can be placed and sized on any dashboard
 - i. Alarm Status: ability to display select alarm sources (building(s), equipment, systems, categories, and status) on any dashboard

- j. Circle and fill gates: Display single values from any point, data log, in the system in either a full circle, half circle, or horizontal fill gauge on any dashboard
- k. Size and position of ability of all items on a dashboard
- l. Ability to select different dashboard themes and import custom themes that can be applied to any dashboard
- m. Save, edit, delete, and save as capability

P. Remote Access / Network Security

- 1. The project's Controls Contractor shall provide secure remote access to the Building Automation System (BAS).
- 2. Secure remote access to the BAS shall not require additional software to be installed on the client device (i.e. VPN client).
- 3. Secure remote access to the BAS shall not require ANY inbound ports on a firewall to be "exposed" or "forwarded".

Q. System Security

- 1. User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
- 2. The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.
- 3. User logon/logoff attempts shall be recorded.
- 4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
- 5. The system shall support Active Directory for user set-up and management
- 6. The system shall track and record all user log-in activity and all changes done at the enterprise level including who made the change, when, what was changed, previous value and new value.

R. On-Line Help and Training

- 1. Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
- 2. On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.

2.3 AS AN ALTERNATE PROVIDE ENTERPRISE COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEMS, CMMS

- A. Provide a CMMS software package that is used to schedule and record operation and preventive/planned maintenance activities associated with facility equipment. The CMMS can generate and prioritize work orders and schedules for staff to support "trouble" calls and to perform periodic/planned equipment maintenance. Upon completion of a work order, performance information, such as the date work was performed, supplies/inventory, and

manhours expended, typically is loaded into the database for tracking, to support future operations/planning.

- B. All systems, and devices shall be defined in the CMMS for each site prior to Owner acceptance of the project.

2.4 ENTERPRISE SYSTEM – INTERFACE TO BUILDING AUTOMATION SYSTEM (BAS)

- A. Provide a new Building Automation System (BAS) to interface with the above-described Enterprise System that will integrate and control all equipment as defined per site associated with this project.
 - 1. The Building Automation System shall be as indicated on the drawings and described in these specifications. System must be fully integrated and coordinated with mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory when available or on site as required as specified. The intent of the BAS is to integrate all mechanical, electrical, plumbing and fire sprinkler equipment into one system for global monitoring, control, and alarming associated with the building. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BAS operators have the capability of managing the building mechanical system to ensure occupant comfort while maintaining energy efficiency.
 - 2. The BAS shall meet open standard protocol communication standards (As defined in System Communications and Field Bus Communications of COMMUNICATIONS) to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects.
 - 3. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems and terminal devices on this project.

2.5 BAS - APPROVED CONTROL SYSTEM MANUFACTURERS

- A. Approved BAS Manufacturers
 - 1. Trane Tracer® - Basis of Design
 - 2. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid.

2.6 BAS - SYSTEM COMMUNICATION

- A. System Communications
 - 1. Each workstation, building controller, and equipment controller communication interface shall utilize the BACnet™ protocol with an Ethernet (IEEE 802.3, 802.11), RS485 (EIA-

485), or Zigbee® (802.15.4) physical interface and an appropriate data link technology as defined in ANSI®/ASHRAE® Standard 135-2012. (e.g. BACnet over IP, BACnet over IPv6, BACnet over MS/TP, BACnet Zigbee).

2. All system controllers shall be BTL listed as a BACnet Building Controller (B-BC) as defined in ANSI®/ASHRAE® Standard 135-2012.
3. All documented status & control points, schedule, alarm, and data-log services or objects shall be available as standard object types as defined in ANSI®/ASHRAE® Standard 135-2012.
4. Each System Controller shall communicate with a network of Custom Application and Application Specific Controllers utilizing one or more of the interfaces documented within Field Bus Communications below.

B. Field Bus Communications

1. BACnet™

- a. All equipment and plant controllers shall be BTL listed as a BACnet Application Specific Controller (B-ASC) or a BACnet Advanced Application Controller (B-AAC) as defined in ANSI®/ASHRAE® Standard 135-2012.
- b. All communication shall conform to ANSI®/ASHRAE® Standard 135-2012.
- c. System Controller shall function as a BACnet router to each unit controller providing a globally unique BACnet Device ID for all BACnet controllers within the system.
- d. BACnet over Zigbee®
 - 1) Communication between System Controller and equipment/plant controllers shall utilize BACnet over Zigbee as defined in ANSI®/ASHRAE® Standard 135-2012.
 - 2) Each equipment controller wireless communication interface shall self-heal to maintain operation in the event of network communication failure.
 - 3) Each zone sensor wireless communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications. Sensing options shall include temperature, relative humidity, CO2, and occupancy.
- e. BACnet over MS/TP
 - 1) Communication between System Controller and equipment/plant controllers shall utilize BACnet over MS/TP as defined in ANSI®/ASHRAE® Standard 135-2012.

2.7 BUILDING CONTROLLER - WEB INTERFACE

A. Provide Building Controller Web Interface.

1. Manufacturer shall provide a user interface with time-of-day schedules, data collection, dashboards, reports and building summary, system applications, and self-expiring timed overrides. Manufacturer shall provide published documents that detail operation, configuration, setup and troubleshooting.
2. The building controller web interface shall be accessible via a web browser without requiring any “plug-ins” (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
3. User Roles
 - a. The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.
 - b. User logon/logoff attempts shall be recorded.
 - c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
4. On-Line Help and Training
 - a. Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
 - b. On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.
5. Equipment & Application Pages
 - a. The building controller web interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - 1) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
 - 2) Historical Data (As defined in Trend Logs section of CONTROLLER SOFTWARE) for the equipment or application without requiring a user to navigate to a Data Log page and perform a filter.
6. Building Controller System Graphics.
 - a. The building operator web interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, primary electrical system, backup electrical system, plumbing systems, potable water systems, fire sprinkler systems and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
 - b. Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.

- c. Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
 - d. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
- 7. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, pumps, generators, solar power systems, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.
- 8. Manual Control and Override
 - a. Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system from the enterprise level only with appropriate classification as defined by the system administrator. The local user shall only be able to view the status of any object and property. The point status shall be available by menu, on graphics or through custom programs.
 - b. Temporary Overrides. The user enterprise user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 - c. Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 - d. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
- 9. Scheduling. - The scheduling application shall provide graphical representation of the day, week, month and exception events.
- 10. Alarm/Event Notification
 - a. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any building operator web interface.
 - 1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - 2) The operator shall be able to acknowledge and add comments to alarms
 - 3) Alarm/event messages shall use full language, easily recognized descriptors.
- 11. Reports and Logs.
 - a. The building operator web interface shall provide a reporting package that allows the operator to select reports.
 - b. The building operator web interface shall provide the ability to schedule reports to run at specified intervals of time.
 - c. The following standard reports shall be available without requiring a user to manually configure the report:

- 1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
- 2) All Points in Override Report: Provide an on demand report showing all overrides in effect.
- 3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation at owner acceptance of the BAS.
- 4) Points report: Provide a report that lists the current value of all points

B. Provide Mobile App Interface

1. Provide mobile (smart phone or tablet) interfaces to the building automation system, compatible with iOS and Android™ operating systems.
2. Controls manufacturer shall provide a phone/tablet interface with the ability to view/override status & setpoints, view/change schedules, view/acknowledge/comment on alarms, and view graphics for all spaces and equipment.
3. This phone/tablet interface shall resize itself appropriately for the size of the interface (i.e. no "pinching & zooming" required).
4. This phone/tablet interface shall function remotely from the facility while following IT security best-practices (e.g. no ports exposed to the internet).
5. The operator interface shall support system access on a mobile device via a mobile app to:
 - a. Alarm log
 - b. System Status
 - c. Equipment status
 - d. Space Status
 - e. Standard Equipment graphics
 - f. Override set points
 - g. Override occupancy
 - h. Acknowledge Alarms
 - i. Comment on Alarms

2.8 BAS – BUILDING CONTROLLER REQUIREMENTS

- A. There shall be one or more independent, standalone microprocessor-based System Controllers to manage the global strategies described in CONTROLLER SOFTWARE section.
1. The controller shall provide a USB communications port for connection to a PC.
 2. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
 3. All System Controllers shall have a real time clock and shall be able to accept a BACnet time synchronization command for automatic time synchronization.
 4. Data shall be shared between networked System Controllers.

5. Serviceability – The System Controller shall have a display on the main board that indicates the current operating mode of the controller.

- B. Controls manufacturer shall provide secure remote access to the Building Automation System (BAS). Secure remote access shall not require IP ports to be "exposed" (i.e. port-forwarded or external public IP addresses) to the Internet. Controls manufacturer shall update secure remote access software as necessary to follow cyber security best practices and respond to cyber security events.

2.9 BAS – BUILDING CONTROLLER SOFTWARE

- A. Manufacturer shall provide standard applications to deliver HVAC system control. Standard applications include Time of Day Scheduling with Optimal Start/Stop, VAV Air Systems Control, Chiller Plant Control, Historical Trend Logs and Trim and Respond. Manufacturer shall provide system optimization strategies for functions such as fan pressure optimization and ventilation optimization.
- B. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the building operator interface.

1. Trend Logs

- a. The system shall harvest trend logs for defined key measurements for each controlled and monitored device and application. Trend logs shall be captured for a minimum of 5 key operating points for each piece of HVAC equipment and HVAC application and stored for no less than 1 year at 15-minute intervals.
- b. Trend logs shall be used by the enterprise system to monitor system status and provide real time commissioning of key system as defined. Commissioning reports shall be provided indicating current operating characteristics of each device indicated and shall compare to the operating characteristics of each device at owner acceptance.

END OF SECTION 230923.01

SECTION 230995 – TRENDING, REMOTE MONITORING AND DATA ANALYTICS

PART 1 - GENERAL

1.1 SUMMARY

- A. The Building Management System (BMS) Contractor shall provide a system trending, remote monitoring capability, and data analytics as part of, or third party add-on to, the Building Management System specified elsewhere in the Contract Documents.
- B. The trending, historical storage and remote monitoring capabilities shall meet or exceed the minimum requirements as outlined in this specification section.
- C. All licenses to enable additional data connections in the future are to be included.

1.2 Data Connection

- A. A building management system providing all analytics requirements put forth in this document is exempt from external data connections if approved by owner and Cx Authority.
- B. The building automation system shall provide reasonable means for third parties to collect historical trend data from the automation system, the following methods are acceptable.
 - 1. SQL Trend storage database
 - a. At a minimum, read only access to trend history database with log in credentials must be provided to owner and third parties free of charge.
 - 2. nHaystack REST API
 - a. The automation system must support the use of the nHaystack data connector.
 - b. The scope of work shall include the automation system technician work needed to enable a third party to establish a data connection in compliance with customers security requirements.

1.3 History Data Trending

- A. Coordination with the Owner and/or CxA for point naming conventions. Point naming conventions complying with the Project Haystack naming methodology are acceptable without further approval.
 - 1. Point naming must be standardized for the site. For example, all VAV box discharge air temperatures must be named exactly the same, whether it is DAT, discharge air temp, or DA Temp.

1.4 Data Analytics

- A. The data analytics portion of the system must meet the following requirements

1.5 ITEMS REQUIRED TO BE COORDINATED WITH OTHER TRADES

- A. The BMS Contractor shall be the fully responsible for coordinating schedule/milestones, critical path items, BMS graphics, point naming conventions, IP integration, etc. required for implementation of a fully functional BMS with trending, archiving and remote monitoring.
- B. Coordination with the Owner and/or Owner's Representative for IP Address(es) and Information Technology requirements.
- C. Final trend point list must be coordinated with Design Mechanical Engineer and CxA.

1.6 WORK BY OTHERS

- A. All work necessary to accomplish the scope outlined in this document shall be provided by the BMS contractor.

1.7 GENERAL

- A. The Building Management System (BMS) shall provide the necessary Hardware, Software, and Network Communication as required to meet the minimum requirements of this specification.

PART 2 - PRODUCTS

2.1 SOFTWARE LICENSE AGREEMENT

- A. Any and all required IDs and passwords or other log in credentials for access to any component or software program shall be provided to the owner.
- B. Any software licensing necessary for external BMS data integration shall be included at no additional cost to the owner. Such licenses shall include nHaystack and oBIX.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs.

- B. Data Access Connectors: Data access can be provided by various connectors options for Bacnet IP, oBix Modbus TCP, Sedona, nHaystack, OPC, MQTT and the web services protocol defined by Project-Haystack.org.
 - 1. In the event that the bidding Contractor's software does not support one of the aforementioned data exchange methods, the bidding Contractor shall submit detailed documentation as to how data exchange can be accomplished through their system.
 - a. Alternate data storage and exchange methodologies, both Hardware and Software are acceptable, but not without written approval from the Owner and/or CxA. Regardless of data storage and exchange methodologies approved by the Owner and/or CxA, access to data from either internal or external IP addresses must be maintained, utilizing standard, open protocols. Some technologies may include, but are not limited to the following.
 - 1) Lynxspring Data Pump
 - 2) BASSG Air Hippo
 - 3) Niagara AX Data Collection

2.3 SERVER FUNCTIONS AND HARDWARE

- A. It shall be possible to provide access to all Network Area Controllers via a single connection to the server.
- B. The server shall provide the following functions, at a minimum:
 - 1. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
 - 2. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
 - 3. The server shall have the storage capacity to store every point in the system, at a maximum 15-minutes interval, for a minimum of 5 years.

PART 3 - EXECUTION

3.1 TRENDING REQUIREMENTS

- A. The points shown in the points list shall be trended in system controllers at the specified intervals. The points list is generic for typical system configurations, final points list to be confirmed with CxA prior to bid
- B. Points List
 - 1. All inputs/outputs
 - 2. Setpoints
 - 3. Occupancy points
 - 4. Energy meter points
 - 5. Typical Dedicated Outdoor Air System Unit

- a. Discharge Air Temp Sensor – 15 min
- b. All Heat Stages - COV
- c. All Cool Stages - COV
- d. Discharge Air Fan Status- COV
- e. Return Air Fan Status- COV
- f. Economizer Damper Positions – 15 min
- g. CO2 Sensors – 15 min
- h. Building Pressure – 15 min
- i. Occupancy Cmd – - COV
- j. Zone Air Temp Sensor – 15 min
- k. Zone Air Temp Set Point – 15 min
- l. Freeze Stat Status - COV
- m. Filter Status – COV
- 6. Typical Terminal Unit Box
 - a. Occupancy Cmd - COV
 - b. Box damper position– 15 min
 - c. Supply air CFM– 15 min
 - d. Airflow set point– 15 min
 - e. Supply air temperature– 15 min
 - f. Zone temperature– 15 min
 - g. Zone temp set point– 15 min

3.2 ACCEPTANCE PROCEDURE & COMMISSIONING

- A. General: The system installation shall be complete and tested for proper operation prior to functional performance testing with the Commissioning Authority (CxA).
- B. System Acceptance
 - 1. A letter shall be submitted to the Engineer & Owner requesting system acceptance. This letter shall certify all trending, historical storage and remote monitoring capabilities are installed and the software programs have been completely exercised for proper equipment operation. When all documentation has been received by the Owner and CxA, and the all items in the Commissioning Issues Log are closed, the system will be accepted. The warranty shall start at this time.
 - 2. The accuracy and completeness of project record documents shall be demonstrated as part of the acceptance procedure.
- C. Trend Data Analysis
 - 1. Trends shall be setup and begin archiving as each piece of equipment and/or system is finished with the BAS Contractors checkout procedure.
 - 2. All points shall be archived for a minimum of 2 years.
 - 3. The installer shall notify the CxA in writing when trends have been configured.
 - 4. The CxA shall analyze trends to prove the system's operation over seasonal variations and update the Commissioning Issues/Benefits log as appropriate through the warranty period.

5. The Installer shall respond to all Commissioning issues in a timely manner at no cost to the owner during the warranty period.

END OF SECTION 230995

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Steel pipe and fittings.
2. Plastic pipe and fittings.
3. Joining materials.
4. Transition fittings.
5. Dielectric fittings.
6. Bypass chemical feeder.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.
5. Bypass chemical feeder.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
- B. PP-R Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
 - 1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 2. Warranty is to be in effect only upon submission by the Contractor to the manufacturer of valid pressure/leak documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Chilled-Water Piping: 150 psig (1034 kPa at 73 deg F (22 deg C).
 - 2. Makeup-Water Piping: 150 psig (1034 kPa at 73 deg F (22 deg C)].
 - 3. Condensate-Drain Piping: 150 deg F (66 deg C).
 - 4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

- F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- G. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 2. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.3 PLASTIC PIPE AND FITTINGS

- A. HDPE Pipe: ASTM D3035. pipe pressure rating to comply with temperature and pressure ratings of code requirements for the applicable service.
- B. Molded PE Fittings: ASTM D2683 or ASTM D3261, ASTM F1055 PE resin, socket, butt-fusion or electro-fusion type, made to match PE pipe dimensions and class.
- C. Polypropylene Pipe: ASTM F2389, pipe pressure rating to comply with temperature and pressure ratings of code requirements for the applicable service.
- D. Polypropylene Fittings: ASTM F2389, socket fusion, butt fusion, electrofusion, or fusion outlet fittings to be used for fusion-welded joints between pipe and fittings.
 - 1. Mechanical fittings and transition fittings to be used where transitions are made to other piping materials or to valves and appurtenances.
 - 2. Polypropylene pipe is to be unthreaded. Threaded transition fittings per ASTM F2389 to be used where a threaded connection is required.
- E. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.
 - 1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

2.4 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, **1/8-inch (3.2-mm)** maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Solvent Cements for PVC Piping: ASTM D2564. Include primer according to ASTM F656.

2.5 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings:
 - 1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
 - 1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Insulating Kits:

1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

2.7 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.
 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be the following:
 1. PP-R plastic piping and fittings with heat fusion joints.
 2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Or other owner pre-approved alternates
- B. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be the following:
 1. PP piping and fittings with heat fusion joints.
 2. HDPE piping and fittings with heat fusion joints
 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. Schedule 40 steel pipe; welded fittings; and welded mechanical joints.
 5. Or other owner pre-approved alternates
- C. Chilled-Water Piping Installed Belowground:
 1. Comply with requirements in Section 232113.13 "Underground Hydronic Piping".
 2. Or other owner pre-approved alternates

- D. Makeup-water piping installed aboveground shall be the following:
 - 1. PP-R plastic piping and fittings with heat fusion joints.
 - 2. Or other owner pre-approved alternates
- E. Condensate-Drain Piping, PVC: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
 - 1. Or other owner pre-approved alternates
- F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 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 piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.

- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
 - 1. Section 230523.11 "Globe Valves for HVAC Piping."
 - 2. Section 230523.12 "Ball Valves for HVAC Piping."
 - 3. Section 230523.13 "Butterfly Valves for HVAC Piping."
 - 4. Section 230523.14 "Check Valves for HVAC Piping."
 - 5. Section 230523.15 "Gate Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- E. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D2657. Minimize number of joints.
- F. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Non-pressure Piping: Join according to ASTM D2855.
- G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.5 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 (DN 65) and Larger: Use dielectric flange kits.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced code, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling
- F. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent
- G. Support vertical runs of HDPE, PVC and PP-R piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

3.8 CHEMICAL TREATMENT

- A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

- B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.10 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 - 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - 6. Prepare written report of testing.
- C. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect pumps for proper rotation.
 - 3. Set makeup water pressure-reducing valves for required system pressure.

4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as chillers to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232113.13 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pre-insulated PVC Piping Systems suitable for Chilled Water, Potable Water, and Low Temperature Process Fluids

1.2 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:

1. Chilled-Water Piping: 100 psig (690 kPa) at 200 deg F (93 deg C).

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Conduit piping.
2. Cased piping.
3. Insulation

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUIT PIPING SYSTEM

A. Underground hydronic piping shall be as described below or other owner pre-approved alternates.

- B. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Insul-Tek Piping Systems, Inc.
 - b. Perma-Pipe, Inc.
 - c. Rovanco Piping Systems, Inc.
 - d. Thermacor Process, L.P.
- C. Carrier pipe shall be C900 DR25 rated pipe. Pre-insulated pipe sections shall be insulated from the bell end to just short of the spigot insertion stop mark.
- D. Insulation shall be polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket, and shall be bonded to both. Insulation shall be rigid, minimum 90% closed cell polyurethane with a minimum 2.0 lbs. per cubic foot density, compressive strength of 30 psi @ 75°F, and coefficient of thermal conductivity (K-Factor) of not higher than 0.16 @ 75°F per ASTM C-518. Maximum operating temperature of urethane shall not exceed 250°F. Insulation thickness shall be specified by calling out appropriate carrier pipe and jacket size combinations as listed on drawing CTSG 5.103 or 5.104.
- E. Jacketing material shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness not less than 100 mils for pipe sizes less than or equal to 12", and 125 mils for jacket sizes larger than 12" to 24. No tape jacket allowed. The inner surface of the HDPE jacket shall be oxidized by means of corona treatment, flame treatment, or other approved methods. This will ensure a secure bond between the jacket and foam insulation preventing any ingress of water at the jacket/ foam interface.
- F. Straight Run Joints are not insulated to allow for expansion and contraction of the gasketed joint.
- G. Fittings shall be PVC with a gasket joint similar to that of the PVC pipe. Fittings are not insulated and are poured in concrete thrust blocks at all changes of direction.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- B. Remove standing water in the bottom of trench.
 - C. Do not backfill piping trench until field quality-control testing has been completed and results approved.
 - D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.
 - E. In conduits, install drain valves at low points and manual air vents at high points.
 - F. Install components with pressure rating equal to or greater than system operating pressure.
 - G. Install piping free of sags and bends.
 - H. Install fittings for changes in direction and branch connections.
 - I. Secure anchors with concrete thrust blocks.
- 3.2 Underground systems shall be buried in a trench of not less than two feet deeper than the top of the pipe and not less than eighteen inches wider than the combined O.D. of all piping systems. A minimum thickness of 24 inches of compacted backfill over the top of the pipe will meet H-20 highway loading.
- 3.3 Trench bottom shall have a minimum of 6" of sand, pea gravel as a cushion for the piping. All field-cutting of the pipe shall be performed in accordance with the manufacturer's installation instructions. At least the center 75% of each section of pre-insulated pipe shall be covered (approximately one foot of cover per 100 psi of test pressure) with select backfill material and all fittings shall be suitably thrust blocked before attempting any pressure tests of the system.
- 3.4 IDENTIFICATION
- A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping.
- 3.5 FIELD QUALITY CONTROL
- A. Perform the following tests and inspections:
 - 1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
 - a. Leave joints exposed for examination during test.

- b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
 - c. Use vents installed at high points to release trapped air while filling system.
- 2. Test hydronic piping as follows:
 - a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure for not less than two hours.
 - b. Examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
- 3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for four hours with no loss of pressure. Repair leaks and retest as required.
- B. Prepare test and inspection reports.

END OF SECTION 232113.13

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523.11 "Globe Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
4. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
5. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
6. Section 230523.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
7. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 2. Ball: Brass or stainless steel.
 - 3. Plug: Resin.
 - 4. Seat: PTFE.
 - 5. End Connections: Threaded or socket.
 - 6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 7. Handle Style: Lever, with memory stop to retain set position.
 - 8. CWP Rating: Minimum 125 psig (860 kPa).
 - 9. Maximum Operating Temperature: 250 deg F (121 deg C).
- B. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
 - 1. Body: Bronze or brass.
 - 2. Disc: Glass and carbon-filled PTFE.
 - 3. Seat: Brass.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Diaphragm: EPT.
 - 6. Low inlet-pressure check valve.
 - 7. Inlet Strainer: Removable without system shutdown.
 - 8. Valve Seat and Stem: Noncorrosive.
 - 9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- C. Diaphragm-Operated Safety Valves: ASME labeled.

1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: Removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Automatic Flow-Control Valves:

1. Body: Brass or ferrous metal.
2. Flow Control Assembly, provide either of the following:
 - a. Piston and Spring Assembly: [**Stainless steel**] [**Corrosion resistant**], tamper proof, self-cleaning, and removable.
 - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig (14- to 550-kPa) differential pressure.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow within plus or minus 10 percent regardless of system pressure fluctuations.
7. Minimum CWP Rating: [**175 psig (1207 kPa)**] [**300 psig (2070 kPa)**].
8. Maximum Operating Temperature: [**200 deg F (93 deg C)**] [**250 deg F (121 deg C)**].

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.

3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/4 (DN 8).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

C. Diaphragm or Bladder-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, [20] [40] [60]-mesh strainer or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shut-off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install throttling-duty or calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

- D. Install tangential or in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- E. Install expansion tanks on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line centrifugal pumps.
2. End-suction centrifugal pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pump.

B. Shop Drawings: For each pump.

C. Delegated-Design Submittal: For each pump.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for pumps, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints.
- C. Seismic Performance: Pumps shall 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."
 - 2. Component Importance Factor: 1.0.

2.2 IN-LINE CENTRIFUGAL PUMPS

- A. The pumps shall be of a horizontal, permanently lubricated type, specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, in cast iron bronze fitted (or all bronze) construction. The pump internals shall be capable of being serviced without disturbing piping connections.
- B. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupler.
- C. The pumps shall have a solid SAE1144 steel shaft supported by two sealed ball bearings. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
- D. Pump shall be equipped with an internally-flushed mechanical seal assembly. Seal assembly shall be the unitized type with stainless steel drive tabs, EPR bellows and seat gasket, stainless steel spring, and be of a carbon silicon-carbide design with the carbon face rotating against a stationary silicon-carbide face.
- E. Bearing assembly shaft shall connect to either a cast bronze impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.
- F. A flexible type coupling shall be employed between the pump and motor.
- G. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.

- H. Pump volute shall be of cast iron design for heating systems or cast bronze for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles, and vent and drain ports.
- I. To ensure alignment the motor shall be mounted to the bearing assembly via a bolted motor bracket assembly, and a rubber motor mount shall be used to assist in aligning the motor shaft with the pump shaft.
- J. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors through 1 HP shall be resilient mounted, motors over 1.5 HP shall be rigid mounted. Motors shall have permanently lubricated ball bearings and must be completely maintenance free. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
- K. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.
- L. Pump manufacturer shall be ISO-9001 certified and be of U.S. manufacturer.
- M. Each pump shall be factory tested and name-plated before shipment and shall be provided with a (3) year warranty from date of installation.

2.3 END-SUCTION CENTRIFUGAL PUMPS

- A. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation. Suitable standard operations at 225°F and 175 PSIG working pressure or optional operations at up to 250°F and 250 PSIG working pressures. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being serviced without disturbing piping connections, electrical motor connections or pump to motor alignment.
- B. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.
- C. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
- D. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless steel shaft sleeve shall be employed to completely cover the wetted area under the seal.
- E. Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines. Seal assembly shall have

Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

- F. Bearing assembly shaft shall connect to a stainless steel impeller. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2016, balance grade G6.3 and secured by a stainless steel locking cap screw or nut.
- G. Pump should be designed to allow for true back pull-out allowing access to the pump's working components, without disturbing motor or piping, for ease of maintenance.
- H. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. Pumps for variable speed application shall be provided with a suitable coupling sleeve. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections. On variable speed applications the coupling sleeve should be constructed of an neoprene material to maximize performance life.
- I. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.
- J. Pump volute shall be of a cast iron design for heating systems with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. (Optional 250 PSIG working pressures are available and are 250# flange drilled.) Volute shall include gauge ports at nozzles, and vent and drain ports.
- K. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.
- L. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2019 for grouted Horizontal Baseplate Design standards.
- M. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.
- N. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2016 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2016 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.
- O. Pump manufacturer shall be ISO-9001 certified.

- P. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.
- Q. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

2.4 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

- 1. Angle pattern.
- 2. 175-psig (1204-kPa) pressure rating, cast-iron body and end cap, pump-inlet fitting.
- 3. Bronze 16-mesh wire startup and bronze permanent strainers with 3/16-inch (4.8-mm) perforations and 51 percent open area).
- 4. Bronze straightening vanes.
- 5. Drain plug.
- 6. Factory-fabricated support.

B. Triple-Duty Valve:

- 1. Angle or straight pattern.
- 2. 175-psig (1204-kPa) pressure rating, cast-iron body, pump-discharge fitting.
- 3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
- 4. Brass valve disc with EPDM rubber seat.
- 5. Type 304 stainless steel valve stem.
- 6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
- 7. Brass gauge ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- D. Comply with pump and coupling manufacturers' written instructions.
- E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check, shutoff, and throttling valves the on discharge side of pumps without variable frequency drives.
- F. Install triple duty valves the on discharge side of pumps with variable frequency drives.
- G. Install suction diffuser and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- H. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- I. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.4 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.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.

- b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
- 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
- 6. Start motor.
- 7. Open discharge valve slowly.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 233113 - DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Plastic materials
5. Sealants and gaskets.
6. Hangers and supports.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 EXPOSED DUCTWORK

- A. All exposed ducts in normally occupied spaces shall have a paint grip surface.

2.2 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger Than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.

2. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 1. Finished for Surfaces Galvanized Coating Designation: G60 (Z180).
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 PLASTIC MATERIALS

A. PVC

1. All exhaust duct piping, sizes 6" through 24", shall be PVC seamless extruded type. This duct pipe shall be extruded from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784, trade name H707 PVC. All extruded PVC duct shall have a maximum flame spread rating of 25 or less per ULC S102.2. All PVC extruded duct shall carry a maximum temperature rating of 140°F. All extruded duct pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer, and shall be stored indoors at the manufacturing site until shipped from the factory. All extruded PVC duct pipe shall be marked with the manufacturer's name or identifying symbol.

2.6 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches (76 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.

8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Equal to Foster 32-19 and Childers CP-146.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 DOUBLE WALL INSULATED DUCTWORK

- A. Where indicated on the plans, provide double wall insulated ductwork with perforated interior liner and exterior paint grip surface. Interior ductwork shall have 1" insulation. Exterior ductwork shall have minimum 2" insulation.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install balancing dampers in all duct branches to grilles, registers, and diffusers. Install as close as possible to branch duct takeoff from larger ducts. Dampers in air distribution devices shall not be used to balance systems.
- D. Install round ducts in maximum practical lengths.
- E. Install ducts with fewest possible joints.
- F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- K. Where ducts pass through non-fire-rated interior partitions and exterior walls whether exposed to view or concealed, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Flanges to have a mill phosphatized finish for painting. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
- L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.
- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. All exposed ducts in normally occupied spaces shall have a paint grip surface.
- B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- C. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.
- D. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- E. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- F. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- G. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS

- A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."

- B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.
- C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.4 DUCT SEALING

- A. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class A.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class A.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class A.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2,

"Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

- D. Hangers Exposed to View: Wire rope hanger and clutcher equal to Ductmate. Install with wire clutcher as close as possible to top of duct.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 DUCT CLEANLINESS

- A. Mechanical equipment including air handlers, rooftop package units, etc. and all ducts and air distribution devices shall be sealed to maintain clean, dust and debris free interiors and are to remain sealed until building construction is complete. When used during construction all supply, return, and transfer ducts shall have filter media installed in all inlets and outlets for protection from construction dust. The architect, engineer, general contractor, construction manager, and/or owner may inspect duct and air distribution devices at any time. If ducts and air distribution devices are found to contain contaminants, the entire duct system will be required to be cleaned per the description below before testing, adjusting, and balancing.
- B. Ducts and air distribution devices not maintained clean and debris free per the description above, and found to contain contaminants are to be cleaned prior to testing, adjusting, and balancing per the following:
 - 1. Use service openings for entry and inspection.
 - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.
 - 2. Particulate Collection and Odor Control:

- a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
3. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
4. Mechanical Cleaning Methodology:
 - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - f. Provide drainage and cleanup for wash-down procedures.
 - g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.
- B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 12.
 - c. SMACNA Leakage Class for Round and Flat Oval: 12.
 2. Ducts Connected to Constant-Volume Air-Handling Units:
 - a. Pressure Class: Positive 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
 - a. Pressure Class: Positive 4-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 4-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
- C. Return Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 12.
 - c. SMACNA Leakage Class for Round and Flat Oval: 12.
 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
- D. Exhaust Ducts:
1. Ducts Connected to Fans Exhausting Air:

- a. Pressure Class: Negative 2-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 12.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
3. Exhaust Ducts Connected to Dust Collection Systems:
 - a. Galvanized Steel Ducts: ASTM A 446 galvanized steel sheet, lock-forming quality, having G90 zinc coating in conformance with ASTM A 90.
 - b. Fabricate and support in accordance with SMACNA 15" pressure class.
 - c. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline.
 - d. Increase duct sizes gradually, not exceeding 15 degrees divergence, maximum of 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
 - e. Fittings shall be formed with double-rolled edges, clamp design and have a built-in gasket.
All duct system pipe and fitting shall be galvanized. All exhaust system ducting shall be round. The interior of all ducts shall be smooth and free from obstructions, especially at the joints.
 - f. Sheet metal pipe shall have the following minimum gauges:
 - 1) 3 inches: 24 gauge
 - 2) 4 inches through 6 inches: 22 gauge
 - 3) 7 inches through 12 inches: 20 gauge.
 - 4) 13 inches through 24 inches: 18 gauge.
 - g. Sheet metal elbows shall be one gauge heavier than above.
 - h. Other sheet metal components (reducers, branches, etc.): 18 gauge
 - i. All branches shall enter main at the large end of a transition at an angle not to exceed 45 degrees. Branch connection should be to the side of the main, not the bottom. Two branches should not enter directly opposite to each other. T type branches are not acceptable. "Saddle" type branches, when required, shall enter main on the side at a 45 degree angle.
 - j. Branches shall enter the main duct laterally (from the side of the duct, not the bottom), at 45 degrees, in the direction of the air flow.
 - k. Duct and fitting joints must be airtight. Apply clear silicone caulking one inch inside each large end, completely around the circumference. Work the fitting into the duct until the duct is up to the bead on the fitting. Drill rivet holes using through both layers of duct. Use steel pop rivets with steel pins. Sheet metal screws are not acceptable.

- l. Slide gates shall be full style, with locking screw and provided for balancing the system. Locate gate near connection to each machine and floor sweep. Do not make a connection to any spark-producing machine, such as a grinding wheel.
 - m. Locate 6-inch floor sweep(s), where shown on the plans. If provided with hinged door, for safety reasons, attach chain from door to vertical duct at 5 feet AFF.
 - n. Suction hoods for wood working shop equipment shall be fabricated and customized to fit each machine and be two gauges heavier than the connecting duct. Hoods shall be free of sharp edges or burrs and reinforced to provide stiffness.
 - o. Flexible hose from branch ducts to hoods shall be kept at a minimum and be material handling type (not PVC), with wire reinforcement.
4. Ducts Connected to Type I Kitchen Hoods Shall Comply with NFPA 96 and be one of the following:
 - a. Factory built grease duct as required for clearance to combustibles.
5. Ducts Connected to Type II Hoods:
 - a. Type 304, stainless-steel sheet.
 - b. Exposed to View: No. 4 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and flanged joints with watertight EPDM gaskets.
 - e. Pressure Class: Positive or negative 2-inch wg.
 - f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - g. SMACNA Leakage Class: 3.
6. Ducts Connected to Dishwashers and Dishwasher Hoods:
 - a. Type 304, stainless-steel sheet.
 - b. Exposed to View: No. 4 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and flanged joints with watertight EPDM gaskets.
 - e. Pressure Class: Positive or negative 2-inch wg.
 - f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - g. SMACNA Leakage Class: 3.
7. Ducts Connected to Fans Exhausting Laboratory and Process (fume hoods, not general classroom or prep room exhaust) Air:
 - a. Type I, Grade I Polyvinyl Chloride (PVC)
 - b. Pressure Class: Positive or negative 3-inch wg.
 - c. Minimum SMACNA Seal Class: A.
 - d. SMACNA Leakage Class: 3.

8. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 12.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 3.
 - c. SMACNA Leakage Class for Round and Flat Oval: 3.
- F. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel.
 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
 3. Aluminum Ducts: Aluminum.
- G. Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.

- b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
 - a. Ducts designed to operate at a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give days' advance notice for testing.
8. The construction manager/general contractor shall witness and document the testing and results.

END OF SECTION 233113

SECTION 233115 - NON-FIBROUS, CLOSED CELL, OUTDOOR DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Non-fibrous, closed cell, outdoor ductwork performance requirements

B. This section does not include:

1. Air passages rated over a continuous internal static pressure of 10" w.g. positive, 10" negative, or with test pressure rating over: 10" w.g. startup and 10" w.g. negative (as documented on product labeling).

C. Delegated Duct Design: Duct construction, including material thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article or the ductwork manufacturer's instructions.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.2 INFORMATIONAL SUBMITTALS

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

B. Shop drawings: Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work including

C. Coordination Drawings: The contractor shall submit duct layout plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct layout indicating sizes and pressure classes.
2. Elevation of top of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Fittings.
5. Duct installation, indicating coordination with general construction, building components including structure, hydronic, plumbing, and sprinkler piping, electrical conduits, and other building services. Indicate proposed duct sizes, elevations, changes in elevation, etc.

6. Suspended ceiling components.
 7. Suspended mechanical equipment including required clearances.
 8. Size and location of access to concealed equipment.
 9. Penetrations of smoke barriers and fire-rated construction.
- D. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.3 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- C. Duct Leakage Class, follow SMACNA Leakage Class 3 or less.

1.4 PRODUCT DELIVERY AND STORAGE

- A. Prevent objectionable aesthetic damage to the outer surface of duct segments during transport and storage.
- B. Store duct segments under cover and protect from excessive moisture prior to installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with the requirements listed below, provide ducts and fittings by one of the manufacturers listed below or an equal product by another manufacturer:
 1. Qduct
 2. Thermaduct

2.2 THERMADUCT RECTANGULAR DUCT AND FITTINGS

- A. Product: Thermaduct.
 1. The panel shall be manufactured of CFC-free Kingspan Kooltherm closed cell rigid thermoset resin thermally bonded on both sides to a factory applied .001" (25 micron) aluminum foil facing reinforced with a fiberglass scrim. An added UV stable, IR

reflective 1000-micron high impact resistant titanium infused vinyl is factory bonded using a full lamination process. The lamination process shall permanently bond the vinyl clad to the outer surfaces of the phenolic foam panel to provide a zero-permeability water tight barrier and to form a structurally insulated panel (SIP) in which to form duct segments. Processes that do not employ a full lamination process are not acceptable. Self-applied adhesives such as tapes, caulks or cladding that incorporate pressure sensitive or spray adhesives are not acceptable.

2. The thermal conductivity shall be no greater than $0.146 \text{ BTU} \cdot \text{in}/\text{Hr} \cdot \text{ft}^2 \cdot ^\circ\text{F}$ ($.018 \text{ W}/\text{m} \cdot ^\circ\text{C}$), the thermal conductivity shall be no greater than $0.146 \text{ BTU} \cdot \text{in}/\text{Hr} \cdot \text{ft}^2 \cdot ^\circ\text{F}$ ($.018 \text{ W}/\text{m} \cdot ^\circ\text{C}$)
3. The density of the Kooltherm foam shall not be less than 3.5 pcf (56 Kg/m³) with a minimum compressive strength of 28 psi (.2 MPa).
4. The standard panel is (31 mm) thickness panel with R-8.1 (1.5 RSI) shall be utilized unless indicated otherwise on the print.
 - a. Maximum Temperature: Continuous rating of 185 degrees F (70 deg C) inside ducts or ambient temperature surrounding ducts.
 - b. Maximum Thermal Conductivity: $0.146 \text{ Btu} \times \text{in.}/\text{h} \times \text{sq. ft.} \times \text{deg F}$ at 75 deg F mean temperature.
 - c. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
 - d. Antimicrobial Agent: Additive for antimicrobial shall not be used but instead, raw product must pass UL bacteria growth testing.
 - e. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
 - f. Required Markings: All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
 - g. All insulation materials shall be closed cell with a closed cell content of >90%.
 - h. R-value:
 - 1) 1 3/16 inch (31 mm) Thick Panel: 8.1 R
 - i. Pressure Class design must be specified prior to fabrication. Manufacturer shall be capable of providing ductwork constructed to the following pressure classes:
 - 1) 2" w.g.
 - 2) 4" w.g.
 - 3) 6" w.g.
 - 4) 8" w.g.
 - 5) 10" w.g.
5. Closure Materials:
 - a. V-Groove Adhesive: Silicone (interior only).
 - b. UV stable 1000 micron high impact resistant titanium infused vinyl (exterior).

- 1) Factory manufactured seamless corners for zero perms.
 - 2) Cohesive bonded over-lap at corner seam covers for zero perms.
 - 3) Water resistant titanium infused welded vinyl seams.
 - 4) Mold and mildew resistant.
 - c. Polymeric Sealing System:
 - 1) Structural Membrane: Aluminum scrim with woven glass fiber with UV stable vinyl clad applied
 - 2) Minimum Seam Cover Width: 2 7/8" inches (75 mm)
 - 3) Sealant: Low VOC.
 - 4) Color: Matched by architect optional.
 - 5) Water resistant.
 - 6) Mold and mildew resistant.
 - d. Duct Connectors.
 - 1) Factory manufactured galvanized 4-bolt flange.
6. Outdoor Cladding
 - a. Thermaduct outdoor Installations: Duct segments shall incorporate UV stable 1000 micron high impact resistant titanium infused vinyl which is introduced during the manufacturing process.
7. Flange coverings
 - a. Flanges are field sealed airtight before flange covers are installed. Flange covering consists of the following:
 - 1) Foam tape insulation with molded 39 mil covers.
 - 2) Air gap (heating only application) with molded 39 mil covers.
8. Reinforcement
 - a. Thermaduct shall provide designed and built with adequate reinforcement to both; withstand air pressure forces from within the duct from blower pressure and shall be built to handle expected snow load for the location where the Thermaduct is being installed. Thermaduct will employ Airtruss™ reinforcement system when both specified static pressure and duct sizes dictate the need. This is a factory installed system and no field installation of the reinforcement system is required.
9. Weight
 - a. Thermaduct shall provide low weight stresses on the building framing and support members. Assembled Thermaduct shall have a weight of 0.86 lbs. per square foot to maximum weight of 2.7 lbs. per square foot (depending on R-value and

reinforcement requirement). Hangers and tie-downs are to be detailed on the manufacturer's installing contractors detail drawings prior to installation but not exceeding 13' for duct girth <84" and 8' for duct girth >85" between hangers and designed to carry the weight and wind load of the ductwork.

PART 3 - EXECUTION

3.1 Shop Fabrication

A. Certification:

1. Ducts shall be detailed and fully factory manufactured by an authorized ThermaDuct, LLC facility system. All fabrication labor will be certified "yellow label" building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).

B. Fabrication

1. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer's written and detailed instructions.
2. Fabricated 90-degree mitered elbows to include turning vanes.
3. Fabricated duct segments in accordance with manufacturer's written details.
4. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
5. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer's detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer's design guide based on specified ductwork size and system pressure.
6. Designed and fabricated duct segments and fittings will be in accordance with "SMACNA Phenolic Duct Construction Standards" latest edition.
7. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for permanent protection against water intrusion.
8. Duct shall be constructed to exceed requirements for snow and wind loads.

3.2 DUCT INSTALLATION

- A. Duct segments shall be installed per the ThermaDuct Contractor Installation Manual by competent HVAC installers.

- B. Install ducts and fittings to comply with manufacturer's installation instructions as follows:
 - 1. Install ducts with fewest possible joints.
 - 2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
 - 3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
 - 4. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
 - 5. Use prescribed duct support spacing as described in this specification and manufacturer's recommendations.
- C. Air Leakage: Duct air leakage rates to be in compliance with "SMACNA HVAC Air Duct Leakage Test Manual" latest version per applicable leakage class based on pressure.

3.3 HANGER AND SUPPORT INSTALLATION

- A. Contractor to ensure that the ductwork system is properly and adequately supported per the Thermaduct Contractor Installation Manual.
 - 1. Ensure that the chosen method is compatible with the specific ductwork system requirements per Thermaduct installation detail drawings. Pre-installation should be provided prior to work commencement by installing contractor for approval.
 - 2. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13 foot (3.96 m) lengths with duct girth less than 84". Larger duct sizes and short segments with duct girth greater than 84" are to be supported at 8 foot centers or less, in accordance with the Thermaduct Contractor's Installation Manual provided prior to work commencement.
- C. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.
- D. The load of such accessories to the ductwork shall be neutralized by the accessory support.

3.4 DUCT CLEANLINESS

- A. Mechanical equipment including air handlers, rooftop package units, etc. and all ducts and air distribution devices shall be sealed to maintain clean, dust and debris free interiors and are to remain sealed until building construction is complete. When used during construction all supply, return, and transfer ducts shall have filter media installed in all inlets and outlets for

protection from construction dust. The architect, engineer, general contractor, construction manager, and/or owner may inspect duct and air distribution devices at any time. If ducts and air distribution devices are found to contain contaminants, the entire duct system will be required to be cleaned per the description below before testing, adjusting, and balancing.

- B. Ducts and air distribution devices not maintained clean and debris free per the description above, and found to contain contaminants are to be cleaned prior to testing, adjusting, and balancing per the following:
1. Use service openings for entry and inspection.
 - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.
 2. Particulate Collection and Odor Control:
 - a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
 3. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
 4. Mechanical Cleaning Methodology:
 - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

- c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
- d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
- e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
- f. Provide drainage and cleanup for wash-down procedures.
- g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.5 FIELD QUALITY CONTROL

- A. Inspection: Arrange for manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions.
 - 1. Remove and replace duct system where inspection indicates that it does not comply with specified requirements.
- B. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
- C. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Ducts designed to operate at a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - 5. Test for leaks before applying external insulation.
 - 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 7. Give days' advance notice for testing.
 - 8. The construction manager/general contractor shall witness and document the testing and results.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Remote volume dampers & operators
4. Control/Motorized dampers.
5. Fire dampers.
6. Smoke Dampers
7. Combination smoke-fire dampers
8. Remote Damper Operators
9. Flange connectors.
10. Turning vanes.
11. Duct-mounted access doors.
12. Flexible connectors.
13. Flexible ducts.
14. Duct accessory hardware.
15. Duct silencers.
16. Louvers

1.2 ACTION SUBMITTALS

- A. Product Data: For each backdraft, pressure relief damper, control damper, fire damper, smoke damper, flexible duct, flexible duct connector, and combination fire/smoke damper to be used on the project.
- B. Shop Drawings: For each backdraft, pressure relief damper, control damper, fire damper, smoke damper, flexible duct, flexible duct connector, and combination fire/smoke damper to be used on the project. Include plans, elevations, sections, details and attachments to other work.
 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Control-damper installations.
 - b. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
 - c. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Description: Gravity balanced.
- B. Maximum Air Velocity: 2000 fpm.
- C. Maximum System Pressure: 3-inch wg (0.8 kPa).
- D. Frame: Hat-shaped, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

- E. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.
- F. Blade Action: Parallel.
- G. Blade Seals: Felt.
- H. Blade Axles:
 - 1. Material: Nonferrous metal.
 - 2. Diameter: 0.20 inch (5 mm).
- I. Tie Bars and Brackets: Aluminum.
- J. Return Spring: Adjustable tension.
- K. Bearings: Steel ball or synthetic pivot bushings.
- L. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage (1.0 mm) minimum.
 - b. Sleeve Length: 6 inches (152 mm) minimum.
 - 6. Screen Mounting: Rear mounted.
 - 7. Screen Material: Galvanized steel.
 - 8. Screen Type: Bird for exhaust systems, Insect for intake systems.
 - 9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Standard leakage rating, with linkage outside airstream.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames:
 - a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch (1.62 mm) thick.
5. Blade Axles: Galvanized steel.
6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch (13-mm) diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 REMOTE VOLUME DAMPERS & OPERATORS

- A. Provide remote volume dampers and actuators where volume dampers are located in inaccessible locations (above gypsum ceilings, etc.)
- B. Damper controller and cable shall be concealed above the ceiling. Cable to consist of Bowden cable .054" stainless steel control wire with a tensile strength of 260,000 lbs. that is encapsulated in 1/16" flexible galvanized spiral wire sheath. Control kit shall consist of 2-5/8" diameter die cast aluminum housing with 3" diameter zinc plated [polished chrome and stainless steel are optional] cover, and 14 gauge steel rack and pinion gear drive capable of delivering 35 in. lbs. of push / pull torque that converts rotary motion to push-pull motion. Control shaft shall be D-style flatted 1/4" diameter with 265-degree rotation providing graduations for positive locking and control, and 1-1/2" linear travel capability. Control kit is designed to be imbedded in the ceiling flush with the finished surface.

- C. Damper(s) to be opposed blade type constructed of .050 minimum heavy duty extruded aluminum frames and blades. All necessary hardware to ensure compatibility with Bowden remote cable control system shall be included. Damper blades to include individual blade bushings for smooth and quiet operation. Damper blades shall rotate between a matched pair of formed and punched 306 stainless steel connecting slide rails which facilitate smooth blade movement and ensure alignment.

2.6 CONTROL/MOTORIZED DAMPERS

- 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. Cesco Products; a division of Mestek, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Lloyd Industries, Inc.
 - 4. McGill AirFlow LLC.
 - 5. Metal Form Manufacturing, Inc.
 - 6. Nailor Industries Inc.
 - 7. NCA Manufacturing, Inc.
 - 8. Pottorff.
 - 9. Ruskin Company.
 - 10. Vent Products Company, Inc.
 - 11. Young Regulator Company.
- B. Frames:
 - 1. Hat shaped.
 - 2. Minimum 16 ga. thick, galvanized sheet steel
 - 3. Mitered and welded corners.
- C. Blades:
 - 1. Multiple blade with maximum blade width of 6 inches (152 mm).
 - 2. Parallel-blade design.
 - 3. Galvanized-steel.
 - 4. 0.064 inch (1.62 mm) thick single skin.
 - 5. Blade Edging: Closed-cell neoprene.
 - 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- D. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - 1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
- E. Bearings:

1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm velocity.
- C. Fire Rating: 1-1/2 and 3 hours.
- D. Frame: Curtain type with blades outside airstream fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 1. Minimum Thickness: 0.05 inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.024-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.8 SMOKE DAMPERS

- A. General Requirements: Label according to UL 555S by an NRTL.
- B. Smoke Detector: Integral, factory wired for single-point connection.
- C. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted, or mechanically attached corners and mounting flange.
- D. Blades: Roll-formed, horizontal, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel.
- E. Leakage: Class I.

- F. Rated pressure and velocity to exceed design airflow conditions.
- G. Mounting Sleeve: Factory-installed, 0.039-inch- (1.0-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- H. Damper Motors: Two-position action.
- I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 5. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - 6. Electrical Connection: 115 V, single phase, 60 Hz.
- J. Accessories:
 - 1. Auxiliary switches for position indication.
 - 2. Test and reset switches, damper mounted.

2.9 COMBINATION FIRE AND SMOKE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm velocity.
- C. Fire Rating: 1-1/2 and 3 hours.
- D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted, or mechanically attached corners and mounting flange.
- E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- F. Smoke Detector: Integral, addressable, factory wired for single-point connection.

- G. Blades: Roll-formed, horizontal, 0.063-inch- thick, galvanized sheet steel.
- H. Leakage: Class I.
- I. Rated pressure and velocity to exceed design airflow conditions.
- J. Mounting Sleeve: Factory-installed, 0.039-inch- thick, galvanized sheet steel; length to suit wall or floor application.
- K. Damper Motors: two-position action.
- L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.

2.10 FLANGE CONNECTORS

- A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gage and Shape: Match connecting ductwork.

2.11 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. Vane Construction: Double wall.

2.12 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.13 DUCT ACCESS PANEL ASSEMBLIES

- A. Labeled according to UL 1978 by an NRTL.
- B. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon steel.

- C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
- E. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.14 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

2.15 FLEXIBLE DUCTS

- A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - 2. Maximum Air Velocity: 4000 fpm (20 m/s).
 - 3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. Clamps: Nylon strap in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: Tape, plus sheet metal screws.

2.16 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.17 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Commercial Acoustics
 2. Dynasonics.
 3. Industrial Noise Control, Inc.
 4. McGill AirFlow LLC.
 5. Price
 6. Ruskin Company.
 7. Vibro-Acoustics.
- B. General Requirements:
 1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Shape; as shown on the equipment schedules on the plans:
 1. Rectangular straight with splitters or baffles.
 2. Round straight with center bodies or pods.

3. Rectangular elbow with splitters or baffles.
 4. Round elbow with center bodies or pods.
 5. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275), galvanized sheet steel, minimum 0.034 inch (0.85 mm) thick.
- E. Inner Casing and Baffles: ASTM A 653/A 653M, G90 (Z275) galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.
- F. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- G. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. Dissipative type with fill material.
 - a. Fill Material: Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be resilient such that it will not crumble or break, and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.
 - b. Erosion Barrier: media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber.
- H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
1. Joints: Lock formed and sealed, continuously welded or flanged connections.
 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- I. Accessories:
1. Factory-installed end caps to prevent contamination during shipping.
 2. Removable splitters.
- J. Source Quality Control: Test according to ASTM E 477.
1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.

2. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

K. Capacities and Characteristics: As indicated on the equipment schedules on the plans.

2.18 LOUVERS

A. Materials:

1. Galvanized-Steel Sheet: ASTM A 653/A 653M, G60 (Z180) zinc coating, mill phosphatized.
2. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are corrosive or incompatible with joined materials.
 - a. Use types and sizes to suit unit installation conditions.
 - b. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
3. Anchors and Inserts: Of type, size, and material required for type of loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.
4. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 except containing no asbestos fibers.

B. Fabrication, General:

1. General: Fabricate louvers and vents to comply with requirements indicated for design, dimensions, materials, joinery, and performance.
2. Assemble louvers in shop to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
3. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
4. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances of louvers, adjoining construction, and perimeter sealant joints.
5. Include supports, anchorages, and accessories required for complete assembly.
6. Provide louver units in continuous vertical assemblies without horizontal joints in sizes illustrated.
7. Provide sill extensions and loose sills made of same material as louvers where indicated or required for drainage to exterior and to prevent water penetrating to interior.
8. Join frame members to one another and to fixed louver blades by concealed from view connections as standard with louver manufacturer.

C. Fixed, Extruded-Aluminum Wall Louvers:

1. Drainable, stationary, Fixed-Blade Louvers: Complying with the following requirements:
 - a. Free Area: 62%.
 - b. Frame Depth: 6 inches.
 - c. Frame Thickness: 0.125 inches.
 - d. Blade Thickness: 0.94 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- C. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- A. Unless otherwise indicated on the plans, install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan and at outside air intakes as close as possible to the exterior.
- B. Install volume dampers at all points on supply, return, and exhaust systems where branches extend from larger ducts to diffusers, register, grilles or other termination points. Install as close as possible to the take off from the larger duct. Install the damper arm on the side or bottom of duct. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 1. Install steel volume dampers in steel ducts.
 2. Install aluminum volume dampers in aluminum ducts.
- C. Set dampers to fully open position before testing, adjusting, and balancing.
- D. Install test holes at fan inlets and outlets and elsewhere as indicated.
- E. Install fire and smoke dampers according to UL listing.
- F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 1. On both sides of duct coils.

2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot (15-m) spacing.
8. Upstream and downstream from turning vanes in ducts larger than 14" on one side.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

G. Install access doors with swing against duct static pressure.

H. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

I. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

J. Install flexible connectors to connect ducts to equipment.

K. Connect flexible ducts to metal ducts with draw bands, plus sheet metal screws.

L. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Ceiling-mounted ventilators.
2. Centrifugal ventilators - roof downblast.
3. Centrifugal ventilators - roof upblast and sidewall.
4. Sidewall propeller fans.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.

- C. Delegated Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale and coordinated with all building trades.
- B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.
- C. Product Certificates: Submit certificates that specified equipment will withstand required wind forces, from manufacturer.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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 application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: HVAC power ventilators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Component Importance Factor: 1.0, 1.5 for fans serving shelters.

- G. Wind Performance: Air-handling units shall withstand the effects of wind determined in accordance with to ASCE/SEI 7 . See Section 230548 "Vibration and Seismic Controls for HVAC." [Section 230548.13 "Vibration Controls for HVAC."

2.2 CEILING-MOUNTED VENTILATORS

- A. Housing: Steel, lined with acoustical insulation.
- B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.
- C. Back-draft damper: Integral.
- D. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
 1. Speed Controller
 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 3. Isolation: Rubber-in-shear vibration isolators.
 4. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 DIRECT DRIVE CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

- A. Housing: Downblast; removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.
- B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- C. Accessories:
 1. Speed controller
 2. Disconnect Switch: Nonfusible type, with thermal-overload protection, factory wired through an internal aluminum conduit.
 3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

- D. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

2.4 DIRECT DRIVE CENTRIFUGAL VENTILATORS - ROOF UPBLAST OR SIDEWALL

- A. Configuration: Centrifugal roof upblast, kitchen and sidewall ventilatorS.
- B. Housing: Removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
 - 2. Provide grease collector on fans serving Type I kitchen hoods.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Accessories:
 - 1. Fan speed controller.
 - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection, factory wired through an internal aluminum conduit.
 - 3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
 - 4. Motorized Dampers (except on fans serving Type I kitchen hoods): Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 - 5. Spark-resistant, all-aluminum wheel construction.
 - 6. Wall Mount Adapter: Attach wall-mounted fan to wall.
 - 7. Grease Hood Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.
- E. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
- F. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.
 - 1. Vented Curb: For kitchen exhaust; 12-inch- (300-mm-) high galvanized steel; unlined, with louvered vents in vertical sides.
 - 2. NFPA 96 code requirements for commercial cooking operations.
 - 3. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.5 SIDEWALL PROPELLER FANS

- A. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- B. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- C. Fan Wheel: Replaceable, aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- D. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Accessories:
 - 1. Fan Speed Controller
 - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 - 3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
 - 4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 - 5. Wall Sleeve: Galvanized steel to match fan and accessory size.
 - 6. Weathershield Hood: Galvanized steel to match fan and accessory size.
 - 7. Weathershield Front Guard: Galvanized steel with expanded metal screen.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.7 SOURCE QUALITY CONTROL

- A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.
- B. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
 - 2. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
 - 3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Install units with clearances for service and maintenance.

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 CONTROL CONNECTIONS

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

3.5 STARTUP SERVICE:

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safeties.

3. Fans and components will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233423

SECTION 233439 - HIGH-VOLUME, LOW-SPEED FANS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes high-volume, low-speed fans.

1.2 DEFINITIONS

- A. HVLS - High volume, low speed.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show 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.
- C. Delegated-Design Submittal: For each HVLS fan.
 - 1. Include design calculations and details for selecting product mounting components and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Seismic-Restraint Details:

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
3. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

- a. For Motor, Including Controls: Ten years from date of Substantial Completion.
- b. For Parts, Including Blades and Hub: Ten years from date of Substantial Completion.
- c. For Labor: One year(s) 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: Listed and labeled to UL 507.
- C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
- D. Comply with NFPA 13 requirements for HVLS fans.
- E. AMCA Compliance:

1. Test HVLS fans according to AMCA 230.
 2. Certify HVLS fan performance according to AMCA 211.
- F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.
- G. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified and the units will be fully operational after the seismic event."
 2. Component Importance Factor: 1.0.

2.2 MANUFACTURERS

- A. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.3 HIGH-VOLUME, LOW-SPEED FANS

- A. Basis of Design: Big Ass Fans Powerfoil D model.
- B. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with variable-speed motor controller.
1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 2. Maximum Operating Temperature: 140 (60) deg F (deg C).
 3. Frame:
 - a. Material: Aluminum.
 - 1) Finish: Paint.
 4. Diameter: 12 (3.7) feet (m).
 5. Blades: Airfoil type.
 - a. Quantity: 6.
 - b. Material: Aluminum.
 - 1) Blade Finish: Anodized.
 6. Motor: Neodymium magnet motor.
 7. Controls: Provide wall-mounted keypad with on/off and variable speed control.

PART 3 - EXECUTION

3.1 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
- B. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- C. Install fan according to manufacturer's published instructions.
- D. Comply with NECA 1 and NFPA 70.
- E. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is 3 feet (0.9 m).
- F. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.
- G. Equipment Mounting:
 - 1. Anchor fan to building structure with manufacturer's recommended mounting bracket for installed condition.
 - 2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
 - 3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- H. Install unit to permit access for maintenance.
- I. Install parts and accessories shipped loose.
- J. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 3. Verify proper motor rotation direction and free fan rotation.

4. Check bearing lubrication.

3.2 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.3 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.
- D. Install control devices furnished by manufacturer, but not factory mounted.
- E. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- F. Protect installed units from damage caused by other work.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- B. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- C. Prepare and submit test and inspection reports.

3.5 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.6 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.

END OF SECTION 233439

SECTION 233533 - LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Listed grease ducts.
2. Access doors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For listed grease ducts.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

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

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in listed grease ducts and field-fabricated grease ducts.

PART 2 - PRODUCTS

2.1 LISTED GREASE DUCTS

- A. Description: Factory-fabricated, -listed, and -labeled, double-wall ducts tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.
- B. Construction: Inner shell and outer jacket separated by 2 layers of Super Wool 607 Plus or Insulfrax Elite Blanket between the inner and outer wall insulation between the inner and outer wall.
 - 1. Inner Shell: Type 430 stainless steel.
 - 2. Outer Jacket: Stainless steel.
- C. Duct joints shall be sealed with 3M Fire Barrier 2000+.
- D. Duct wall assembly shall be tested and listed at 3/4" or zero inch clearance, according to classifications
- E. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at 1500 deg F (816 deg C) minimum.
- F. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.
- G. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.
- H. Grease Duct Supports: Construct duct bracing and supports from non-combustible material.
 - 1. Design bracing and supports to carry static and seismic loads within stress limitations of the International Building Code.
 - 2. Ensure that bolts, screws, rivets and other mechanical fasteners do not penetrate duct walls.
- I. Comply with ASTM E2336.
- J. Factory Tests: Test and inspect fire resistance of grease duct system according to ASTM E2336.

2.2 ACCESS DOORS

- A. Description: Factory-fabricated, -listed, and -labeled, double-wall maintenance access doors tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.
 - 1. Construction: 0.0625 inch (1.6 mm)] ASTM A666, stainless-steel inner shell and stainless-steel outer cover with two handles.
 - 2. Fasteners: Stainless-steel bolts and wing nuts.
 - a. Ensure that bolts do not penetrate interior of duct space.
 - 3. Personnel Access Door Dimensions: [22 x 20 inches (559 x 508 mm)] [24 x 24 inches (610 x 610 mm)] <Insert dimensions>.
 - 4. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Coordinate connections to kitchen exhaust hoods with requirements in Section 233813 "Commercial-Kitchen Hoods."
- B. Coordinate firestopping where grease ducts penetrate fire separations with requirements in Section 078413 "Penetration Firestopping."
- C. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211 and UL 2221, whichever is most stringent.
- D. Install airtight personnel and maintenance access doors where indicated.
- E. Seal between sections of grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- F. Connections: Make grease duct connections according to the International Mechanical Code.
 - 1. Grease duct to exhaust fan connections: Connect grease ducts to inlet side of fan using flanges, gaskets, and bolts.
 - 2. Grease duct to hood connections:
 - a. Make grease duct to hood joints connections using internal or external continuously welded or brazed joints.

- b. Make watertight grease duct to hood joints connections using flanges, gaskets, and bolts.
- G. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on kitchen hoods.
 - 1. Securely attach supports and bracing to structure.
- H. Repair damage to adjacent materials caused by listed kitchen ventilation system exhaust ducts installation.

3.2 FIELD QUALITY CONTROL

- A. Perform air leakage test before concealment of any portion of the grease duct system.

END OF SECTION 233533

SECTION 233616 - VARIABLE AIR VOLUME SINGLE DUCT TERMINAL UNITS (SINGLE)

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Single Duct Terminal Units.
- B. Integral terminal unit controls.
 - 1. Direct digital.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 230923 - Controls and Instrumentation: Installation and wiring of thermostats and other control components.

1.3 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. None

1.4 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. NFPA 70 - Electric Duct Heaters.
- D. UL 1995, Heating and Cooling Equipment.
- E. CUL C22.2 No. 236, Heating and Cooling Equipment.
- F. AHRI 880 - Air-Conditioning and Refrigeration Institute Standard Rating Conditions for Air Terminals.
- G. AHRI 885 - Air-Conditioning, Heating and Refrigeration Institute Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.
- H. ASTM A 527 (Steel Sheet, Zinc Coated Galvanized).

1.5 SUBMITTALS

- A. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.
- B. Submit product performance data indicating design air flow, minimum airflow, minimum static pressure drop.
- C. Submit unit casing and damper air leakage rates in accordance with ASHRAE Standard 130.
- D. Submit installation, operation and maintenance documentation.

1.6 SYSTEM RESPONSIBILITY

- A. The contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the one used as "basis of design".
- B. The duct system is computer designed for air balance and noise control using the performance data of the listed manufacturer. Substituting another VAV terminal unit manufacturer may require changes in the system design. These changes may include, but are not limited to, changes in ductwork size or layout, fittings, controls, building structure and piping. The installing contractor, upon substituting an approved alternate, must submit a computerized duct design showing system pressure requirements and acoustic data for the complete duct layout.
- C. The VAV system, including terminal units, direct digital controls and ATC/Building Management System shall be furnished by a single manufacturer who shall be responsible for system performance. If the terminals unit supplier is different from the control system supplier, then one of the two suppliers must bear sole responsibility for proper system performance. The supplier bearing responsibility shall be identified at the time of submittal.

1.7 WARRANTY

- A. Provide a full parts and labor warranty for two year from project substantial completion acceptance by owner, whichever occurs first.
- B. Provide a full parts warranty for five year from project substantial completion acceptance by owner, whichever occurs first.
- C. Contractor to certify and provide warranty service within 4 hours to each site by factory trained personnel once informed by the owner of a problem.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. GENERAL

1. Manufacturer shall participate in the AHRI Certification program. Unit performance data shall be rated in accordance with AHRI Standard 880. The manufacturer shall display the AHRI Symbol on all units.

B. APPROVED MANUFACTURERS

1. Trane
2. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid. Equal system must have screw compressor and meet the specification including all scheduled performance.

- C. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval.

2.2 Single duct terminal units.

- A. Ceiling mounted primary air control terminal units for connection to a single 5 in. w.g. maximum pressure duct of a central air distribution system. Terminals units may be provided with controls and integral heating coils.
- B. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory-set air flow, minimum factory-set air flow, and coil type.

2.3 FABRICATION

- A. Casings: Units shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 18-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet) side and unit casing.
- B. Assembly: Primary air control damper, airflow sensor, controls and optional heating coil in single assembly.

2.4 PRIMARY AIR CONTROL DAMPER ASSEMBLY

- A. Construct damper assembly from a minimum of 18 gauge galvanized steel on the primary air side of the terminal. Blade shall incorporate a full closed cell damper seal to minimize leakage.

Damper blade shall be a minimum of 0.10 in. thickness. Maximum damper leak rate shall not exceed 1% of damper nominal CFM at 4 in. wg. differential pressure.

- B. Construct damper assembly from a minimum of 18 gauge galvanized steel on the primary air side of the terminal. Blade shall incorporate a full closed cell damper seal to minimize leakage. Damper blade shall be a minimum of 0.10 in. thickness. Maximum damper leak rate shall not exceed scheduled air leakage rate.
- C. Locate primary air control damper assembly inside unit casing. Construct the damper assembly from extruded aluminum and/or a minimum 22 gauge galvanized steel components. Maximum damper leak rate shall not exceed 6% of damper nominal CFM at 3 in. wg. Differential pressure.
- D. Locate primary air control damper assembly inside unit casing. Construct the damper assembly from extruded aluminum and/or a minimum 22 gauge galvanized steel components. Maximum damper leak rate shall not exceed scheduled air leakage rate at scheduled inlet pressure.
- E. Damper assembly shall be constructed self-lubricating bearings and contain a mechanical stop.
- F. Primary Damper Shaft shall have a position indicator stamped on the end of the shaft to identify damper position without disassembly of duct, unit casing, or removal of the control box cover.
- G. Provide damper assembly with integral flow sensor. Flow sensor shall be provided regardless of control type. Flow sensor shall be a 16-point (minimum 8-points on high pressure side and 8-points on low pressure side), averaging ring or cross type. Bar or single point sensing type is not acceptable. Damper assembly shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.
- H. Flow sensor transducer shall not be integral to the unit controller.
- I. Flow coefficient calibration data shall be provided for each terminal unit at or near the unit inlet.
- J. Integral flow sensor pressure transducer shall be pressure tested, with air, prior field installation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.2 ADJUSTING

- A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design air flow to 25 percent nominal air flow for cooling only units and 30 percent for units with heating coils.

END OF SECTION 233616

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 DIFFUSERS, REGISTERS AND GRILLES

- A. Material: Aluminum
- B. Dampers: None.

2.2 See the equipment schedules on the plans for descriptions, accessories, performance, etc.

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233716 – FABRIC AIR-DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fabric ducts and fittings.

1.3 QUALITY ASSURANCE

- A. Building Codes and Standards:
 - 1. Product must be classified by Underwriter's Laboratories in accordance with the 25/50 flame spread/smoke developed requirements of NFPA 90-A.
 - 2. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.
- B. Design and Quality Control:
 - 1. Manufacturer must have documented design support information including duct sizing, vent and orifice location, vent and orifice sizing, length, and suspension. Parameters for design, including maximum air temperature, velocity, pressure and fabric permeability, shall be considered and documented.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications on materials and manufactured products used for work of this Section.
- B. Building Code Data: Submit UL file number under which product is classified by Underwriter's Laboratories.
- C. Delegated Design: Submit manufacturer's design calculations, drawings, supporting documentation etc. showing the proposed fabric duct systems will provide the required stable, quiet performance (maximum NC level of 40 from the entirety of the fabric duct system) at the

airflows and pressures proposed to provide terminal velocity of 50 feet per minute maximum at 7'-0" above finished floor unless noted otherwise in the construction documents. Submit layout plans showing fabric types, orifice sizes and locations, supports, fittings and appurtenances required and coordination with other elements of the building construction.

- D. Color Samples: Submit physical color samples for color selection by architect.

1.5 WARRANTY

- A. Manufacturer must provide a 10 year non-prorated warranty program for products supplied for the fabric portion of this system.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Protect fabric air dispersion systems from damage during shipping, storage and handling.
- B. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.

PART 2 - PRODUCTS

2.1 FABRIC AIR DISPERSION SYSTEM:

- A. Fabric: Air diffusers shall be constructed of a coated woven fire retardant fabric complying with the following physical characteristics:
1. Fabric Construction: 100% polyester.
 2. Coating: Air permeable coating.
 3. Weight: 5.2 oz./yd² per ASTM D3776.
 4. Color: To be selected by the Architect during submittals.
 5. Air Permeability: As required to achieve design parameters outlined in delegated design paragraph above.
 6. Temperature Range: 0 degrees F to 180 degrees F.
 7. Fire Retardancy: Classified by Underwriters Laboratories in accordance with the flame spread/smoke developed requirements of NFPA 90-A.
- B. Systems Fabrication Requirements:
1. Air dispersion accomplished by linear vent to consist of many open orifices rather than a mesh style vent to reduce maintenance requirements.
 2. Size and location of vents to be specified and approved by manufacturer to provide even air distribution and maximum 50 fpm terminal air velocity at 7'-0" above finished floor.

3. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via zip screw fastener supplied by Contractor.
4. Inlet connection includes zipper for easy removal/maintenance.
5. Lengths to include required zippers as specified by manufacturer.
6. System to include adjustable flow devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.
7. End cap includes zipper for easy maintenance.
8. Fabric system shall include connectors to accommodate suspension system listed below.
9. Any deviation from a straight run shall be made using a gored elbow or an efficiency tee. Normal 90 degree elbows are 5 gores and the radius of the elbow is 1.5 times the diameter of the fabric duct.

C. Design Parameters:

1. Manufacturer shall verify layout and design of fabric duct systems including duct sizing, vent and orifice location, vent and orifice sizing, length, and suspension. Parameters for design, including maximum air temperature, velocity, pressure and fabric permeability, shall be considered and documented.
2. Fabric air diffuser system shall deliver the required CFM and not produce noise levels above 40 NC.
 - a. Provide test data indicating the fabric duct noise levels at the given airflows and duct sizes.
 - b. In the absence of test data, provide a guarantee that the fabric duct system will not produce noise in excess of the specified value.
3. Fabric air diffusers shall be designed from 0.25" water gage minimum to 3.1 inches maximum, with 0.5 inch as the standard.
4. Fabric air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
5. Design CFM, static pressure and diffuser length shall be designed or approved by the manufacturer.
6. Do not use fabric diffusers in concealed locations.
7. Use fabric diffusers only for positive pressure air distribution components of the mechanical ventilation system.

D. Fabric Tensioning System: Air diffusers shall be constructed with internal tensioning frame.

1. System shall consist of an internal 360 degree hoop system, spaced 5' on center (equivalent to Ductsox IHS).

E. Two Row Cable Hanger System

1. Systems shall be installed 1-1/2" above the 10 and 2 o'clock locations. Textile system attachment to cable shall be made using Gliders spaced every 24 inches. Required for

systems of 32" – 59" diameter. Available for systems less than 32" diameter. Cable suspension hardware to include cable, eye bolts, thimbles, cable clamps, and turnbuckle(s) as required.

2. Cable suspension options(must specify if multiple on same project)
3. Galvanized steel cable
4. Stainless steel cable
5. Impregnated steel cable (required for natatorium applications)

PART 3 - INSTALLATION

3.1 INSTALLATION OF FABRIC AIR DISPERSION SYSTEM:

- A. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

3.2 CLEANING AND PROTECTION:

- A. Clean air handling unit and ductwork prior to the fabric duct system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.
- B. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.
- C. If fabric duct systems become soiled during installation, they should be removed and cleaned following the manufacturer's standard terms of laundry.

END OF SECTION 233116

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Hooded ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For gravity ventilators.

1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

C. Samples: For each exposed product and for each color and texture specified.

D. Delegated Design Submittal: For shop-fabricated ventilators 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 and assembly of shop-fabricated ventilators.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates for ventilators, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.5 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design ventilators.
- B. Structural Performance: Ventilators shall withstand the effects of gravity loads and wind loads and stresses within limits and under conditions without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Consider wind pressures to act normal to the face of the building.
 - 1. See Section 230548 "Vibration and Seismic Controls for HVAC for wind-load requirements.
- C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.0 (except shelters which shall be 1.5).
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
- G. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

2.2 FABRICATION

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

- A. Description: Multitier rectangular louvered penthouse for intake and relief air.
- B. Construction:
 - 1. Material: All-welded assembly with 4-inch (100-mm-deep louvers, mitered corners, and aluminum sheet roof.
 - 2. Frame and Blade Material, Extruded Aluminum: Thickness required to comply with structural performance requirements, but not less than 0.080 (2.0) inch (mm) for frames and 0.080 (2.0) inch (mm) for blades with condensate deflectors.
 - 3. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.
 - 4. Bird Screening (for reliefs or exhausts): Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch- (19-mm-) diamond mesh wire.
 - 5. Insect Screening (for intakes): Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire.
 - 6. Galvanized-Steel Sheet Finish:
 - a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.

C. Dampers:

1. Location: Curb damper tray.
2. Control: Motorized.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

2.4 HOODED VENTILATORS

A. Description: Hooded rectangular or round penthouse for intake or relief air.

B. Construction:

1. Material, Aluminum: Thickness required to comply with structural performance requirements, but not less than 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood; suitably reinforced.
2. Bird Screening (for relief or exhausts): Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch (19-mm) diamond mesh wire.
3. Insect Screening (for intakes): Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire.

C. Dampers:

1. Location: Curb damper tray.
2. Control: Motorized.
3. Tray: Provide damper tray or shelf with opening.

2.5 SOURCE QUALITY CONTROL

A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

2.6 MATERIALS

A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.

2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
- D. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with zinc-plated hardware , that comply with the wind and seismic fastening requirements. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."
- C. Install gravity ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.
- F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- I. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

END OF SECTION 233723

SECTION 233813 - COMMERCIAL-KITCHEN HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Commercial-kitchen hoods, Type I.
2. Commercial-kitchen hoods, Type II.
3. Residential style NFPA 101 compliant hoods

B. Related Requirements:

1. Section 233533 "Listed Kitchen Ventilation System Exhaust Ducts" for fire-rated ducts connecting to kitchen hoods.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Filters/baffles.
2. Fire-suppression systems.
3. Luminaires.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct connection sizes, and attachments to other work.
2. Show cooking equipment plan and elevation to confirm minimum code-required overhang.
3. Indicate performance, exhaust and makeup air airflow, and pressure loss at actual Project-site elevation.
4. Show control cabinets.
5. Show fire-protection cylinders, piping, actuation devices, and manual control devices.
6. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
7. Design Calculations: Calculate requirements for selecting seismic restraints.
8. Include diagrams for power, signal, and control wiring.
9. Duct Connections: Detail connections between ducts and hoods, including access doors and panels.

10. Piping Diagrams: Detail fire-suppression piping and components and differentiate between manufacturer-installed and field-installed piping. Show cooking equipment plan and elevation to illustrate fire-suppression nozzle locations.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Seismic Qualification Data: Submit certification that commercial-kitchen hoods, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D 1.1M, "Structural Welding Code - Steel," for hangers and supports; and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for joint and seam welding.

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.

2.2 HOOD MATERIALS

- A. Stainless-Steel Sheet: ASTM A666, Type 304.
 1. Minimum Thickness: 0.037 inch (0.94 mm) .
 2. Finish: Comply with SSINA's "Finishes for Stainless Steel" for recommendations for applying and designating finishes.
 - a. Finish shall be free from tool and die marks and stretch lines and shall have uniform, directionally textured, polished finish indicated, free of cross scratches. Grain shall run with long dimension of each piece.
 3. Concealed Stainless-Steel Surfaces: ASTM A480/A480M, No. 2B finish (bright, cold-rolled, unpolished finish).
 4. Exposed Surfaces: ASTM A480/A480M, No. 3 finish (intermediate polished surface).

5. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- B. Zinc-Coated Steel Shapes: ASTM A36/A36M, zinc coated according to ASTM A123/A123M requirements.
- C. Sealant: ASTM C920; Type S, Grade NS, Class 25, Use NT. Elastomeric sealant shall be NSF certified for commercial-kitchen hood application. Sealants, when cured and washed, shall comply with requirements in 21 CFR 177.2600, for use in areas that come in contact with food.
 1. Color: As selected by Architect from manufacturer's full range.
 2. Backer Rod: Closed-cell polyethylene, in diameter larger than joint width.
- D. Sound Dampening: NSF-certified, non-absorbent, hard-drying, sound-deadening compound for permanent adhesion to metal in minimum 1/8-inch (3-mm) thickness that does not chip, flake, or blister.
- E. Gaskets: NSF certified for end-use application indicated; of resilient rubber, neoprene, or PVC that is nontoxic, stable, odorless, nonabsorbent, and unaffected by exposure to foods and cleaning compounds, and that passes testing according to UL 710.

2.3 GENERAL HOOD FABRICATION REQUIREMENTS

- A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.
 1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.
 2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.
 3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.
 4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.
 5. After zinc-coated steel is welded, clean welds and abraded areas and apply SSPC-Paint 20, high-zinc-dust-content, galvanizing repair paint to comply with ASTM A780/A780M.
- B. For metal butt joints, comply with SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."
- C. Where stainless steel is joined to a dissimilar metal, use stainless-steel welding material or fastening devices.

- D. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.
- E. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.
- F. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.
- G. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.
- H. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.
- I. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets unless otherwise indicated.
- J. Fabricate seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."
- K. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."
- L. Fabricate enclosure panels to ceiling and wall as follows:
 - 1. Wall Offset Spacer: Minimum of 3 inches (75 mm).
 - 2. Wall Shelves and Overshelves: Fabricate according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," with minimum 0.0625-inch- (1.58-mm-) thick, stainless-steel shelf tops.

2.4 EXHAUST HOOD FABRICATION, TYPE I HOOD

- A. Weld all joints exposed to grease with continuous welds, and make filters/baffles or grease extractors and makeup air diffusers easily accessible for cleaning.
 - 1. Fabricate hoods according to NSF 2, "Food Equipment."
 - 2. Hoods shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction.
 - 3. Duct Collars: Minimum 0.0598-inch- (1.5-mm-) thick steel at least 3 inches (75 mm) long, continuously welded to top of hood and at corners. Fabricate a collar with a 0.5-inch- (13-mm-) wide duct flange.
- B. Hood Configuration: Exhaust and makeup air.
 - 1. Makeup air shall be introduced through front of canopy through perforated diffusers and/or supply-air registers with adjustable guide vanes.

2. Makeup air shall be introduced through laminar-flow-type, perforated metal panels on front of hood canopy.
- C. Filters/Baffles: Removable, stainless-steel. Fabricate stainless steel for filter frame and removable collection cup and pitched trough. Exposed surfaces shall be pitched to drain to collection cup. Filters/baffles shall be tested according to UL 1046, "Safety for Grease Filters for Exhaust Ducts," by an NRTL acceptable to authorities having jurisdiction.
- D. Luminaires: LED fixtures and lamps with lenses sealed vapor tight. Wiring shall be in conduit on hood exterior. Number and location of luminaires shall provide a minimum of 70 fc (753 lx) at 30 inches (762 mm) above finished floor.
 1. Light switches shall be mounted on wall adjacent to hood or in wall mounted hood control panel.
- E. Comply with hood control requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- F. Hood Controls: Wall-mounting control cabinet, factory wired to control groups of adjacent hoods, and fabricated of stainless steel.
 1. Exhaust Fan: On-off switches shall start and stop the exhaust fan. Interlock exhaust fan with makeup air supply fan to operate simultaneously. Interlock exhaust fan with fire-suppression system to operate fan(s) during fire-suppression-agent release and to remain in operation until manually stopped. Include red pilot light to indicate fan operation.
 2. Exhaust Fan Interlock: Factory wire the exhaust fan starters in a single control cabinet for adjacent hoods to operate together.
 3. High-Temperature Control: Alarm shall sound and cooking equipment shall shut down before hood discharge temperature rises to actuation temperature of fire-suppression system.

2.5 EXHAUST HOOD FABRICATION, TYPE II HOOD

- A. Fabricate hoods according to NSF 2, "Food Equipment."
- B. Hood Configuration: Exhaust and makeup air.
- C. Hood Type: Heat and vapor removal.
- D. Condensate Hood Baffles: Removable, stainless-steel baffles to drain into a hood drain trough, and stainless-steel drain piping.
- E. Luminaires: LED luminaires and lamps with lenses sealed vapor tight. Wiring shall be installed in stainless-steel conduit on hood exterior. Number and location of luminaires shall provide a minimum of 70 fc (753 lx) at 30 inches (762 mm) above finished floor.

1. Light switches shall be mounted on wall adjacent to hood or in wall mounted hood control panel.

2.6 RESIDENTIAL STYLE NFPA 101 COMPLIANT HOODS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 1. Accurex
 2. Denlar
- B. The hood shall be constructed of 18 & 20 gauge (type 304) polished stainless steel. Hood shall have fire suppression system factory installed into the hood system. Activation of the mechanical fire suppression system shall be by 212 or 280-degree fusible link (30" vs. 36" sizes). Fire suppression agent will be a low PH wet chemical suppressant. Unit shall include centrifugal fan with air delivery to meet NFPA 101. Unit shall include fuel shutdown option for Gas and Electric. The hood system will also have multiple alarm and monitoring contacts factory installed into the hood.
- C. Hood system include commercial-grade grease extractor type, high efficiency cartridge style baffle filters of adequate number and sizes to ensure optimum performance in accordance with manufacturer's published information. The filter housing shall terminate in a pitched, full-length grease trough, which shall drain into a removable grease container.
- D. Shatter proof light fixtures shall be included in the hood system. Wiring shall conform to the requirements of the National Electrical Code (NEC #70).
- E. Pre-Installed Fire protection system to provide duct entry, plenum, and surface protection for hood system and equipment located below ventilator.
- F. System to included shunt trip breaker and gas solenoid valve for power and fuel shutoff of equipment located below ventilator during system actuation.
- G. Environmental Monitoring / Internal Monitoring / Pre-Suppression
 1. Two temperature sensors shall be located on the inner face of the hood; one at a medium set point, the other at high. Under cooking conditions, when the medium set point is reached, the fan is turned on high. This feature dissipates the heat from the area but also draws it into the unit, past the fusible links in the system. If temperatures continue to rise and the high temperature set point is reached, the system reacts by shutting down power or gas to the range prior to suppression system release. When this occurs, the unit's internal alarm is activated so that occupants are notified that the system is working to prevent further escalation of a potential fire. This is considered two stages of pre-suppression, where the unit is interacting with the cooking environment - working to minimize the risk of a fire event

Should temperatures continue to rise, fire is present. The fusible links will melt, mechanically actuating the suppression system and releasing a low PH wet chemical agent across the cook-top. At actuation, the system will also make a second attempt to shut down power or gas to the range; in the event of a flash-fire, or something that happens too quickly to register with the temperature sensors. The system will continue to sound its internal alarm while also communicating a "fire code" back to a monitored alarm panel.

A PLC Self-Monitoring-System will monitor the entire suppression assembly for completeness and continuity. If the suppression system is ever compromised through a loss of pressure or broken connection, or tampering of any kind, the unit reacts by shutting down power to the range. In this case the suppression system is compromised therefor the range shouldn't be in use. Under this condition, the system communicates a separate "maintenance code" saying that the unit is down and needs service. When preemptive shutdown occurs, the system and the cooking equipment will not come back on-line until the XRRS is reset.

H. Options

1. Manual Pull Station – Mechanical assembly allowing the fire suppression system to be actuated manually normally located at the point of egress. See plans for location
2. The CLOCKBOX – Cooking Element Time-Out System allowing for separate control functionality over when the appliance is used.
3. NSF – The hood system shall be upgraded to the NSF Standard
4. Handicapped Accessible Controls (ADA) – Separate control system designed to mirror the front-end controls of the hood, to be installed at under counter-top height (ONE HOOD PER ROOM, SEE PLANS FOR LOCATION)
5. NFPA101 Upgrade – Combines manual pull station, clockbox, and upgraded fan to deliver >500cfm in order to comply with the requirements of the NFPA Life Safety Code.

2.7 FIRE-SUPPRESSION SYSTEM, WET CHEMICAL

- A. Description: Engineered distribution piping designed for automatic detection and release or manual release of fire-suppression agent by hood operator. Fire-suppression system shall be listed and labeled for complying with NFPA 17A, "Wet Chemical Extinguishing Systems," by a qualified testing agency acceptable to authorities having jurisdiction.

1. Steel Pipe, NPS 2 (DN 50) and Smaller: ASTM A53/A53M, Type S, Grade A, Schedule 40, plain ends.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
3. Piping, fusible links and release mechanism, tank containing the suppression agent, and controls shall be factory installed. Controls shall be in stainless-steel control cabinet mounted on wall. Furnish manual pull station for wall mounting. Exposed piping shall be covered with chrome-plated aluminum tubing. Exposed fittings shall be chrome plated.
4. Liquid Extinguishing Agent: Noncorrosive, low-pH liquid.

5. Furnish electric-operated gas shutoff valve with clearly marked open and closed indicator for field installation.
6. Fire-suppression system controls shall be integrated with controls for fans, lights, and fuel supply and located in a single cabinet for each group of hoods immediately adjacent.
7. Wiring shall have color-coded, numbered terminal blocks and grounding bar. Spare terminals for fire alarm, optional wiring to start fan with fire alarm, red pilot light to indicate fan operation, and control switches shall all be factory wired in control cabinet with relays or starters. Include spare terminals for fire alarm, and wiring to start fan with fire alarm.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Coordinate equipment layout and installation with adjacent Work, including luminaires, HVAC equipment, plumbing, and fire-suppression system components.
- B. Complete field assembly of hoods where required.
 1. Make closed butt and contact joints that do not require filler.
 2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in "General Hood Fabrication Requirements" Article.
- C. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, filters/baffles, grease extractor, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.
- D. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners unless otherwise indicated.
- E. Install hoods to operate free from vibration.
- F. Install seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."
- G. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at 48 inches (1200 mm) o.c. maximum.
- H. Install sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.
- I. Install lamps, with maximum recommended wattage, in equipment with integral lighting.
- J. Set initial temperatures, and calibrate sensors.

- K. Set field-adjustable switches.
- L. Connect ducts according to requirements in Section 233300 "Air Duct Accessories." Install flexible connectors on makeup air supply duct. Weld exhaust-duct connections with continuous liquidtight joint.
- M. Install fire-suppression piping for remote-mounted suppression systems according to NFPA 17A, "Wet Chemical Extinguishing Systems."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Perform hood performance tests required by authorities having jurisdiction.
 - 4. Perform fire-suppression system performance tests required by authorities having jurisdiction.
- B. Commercial-kitchen hoods will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 233813

SECTION 236426.13 - AIR-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes design, performance criteria, refrigerants, controls, and installation requirements for air-cooled rotary screw packaged chillers.

1.2 REFERENCES

- A. AHRI 550/590 - Standard for Water Chilling Packages using the Vapor Compression Cycle
- B. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
- C. ASHRAE 15 - Safety Code for Mechanical Refrigeration
- D. ASHRAE 90.1 - Energy Efficient Design of New Buildings
- E. ASME - Boiler and Pressure Vessel Code SEC VIII, Division 1
- F. UL 1995 - Central Cooling Air Conditioners
- G. ASTM B117 - Standard Method of Salt Spray (Fog) Testing
- H. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- I. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products
- J. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments
- K. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.
- L. ISO 9001
- M. California Administrative Code - Title 24

1.3 SUBMITTALS

- A. Submit dimensional plan and elevation view drawings, weights and loadings, required clearances, location and size of all field connections, electrical requirements and wiring diagrams.
- B. Submit product data indicating rated capacities, accessories and any special data.

- C. Submit manufacturer's installation instructions.

1.4 REGULATORY REQUIREMENTS

- A. Comply with codes and standards specified.
- B. Chiller must be built in an ISO 9001 classified facility.

1.5 VERIFICATION OF CAPACITY AND EFFICIENCY

- A. All proposals for chiller performance must include an AHRI approved selection method. Verification of date and version of computer program selection or catalog is available through AHRI.

1.6 DELIVERY, HANDLING AND STORAGE

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting chillers.
- B. Chiller shall be capable of withstanding -40°F (-40°C) to 158°F (70°C) storage temperatures for an indefinite period of time.

1.7 WARRANTY

- A. Provide a full parts and labor warranty for two year from project substantial completion acceptance by owner, whichever occurs first.
- B. Provide a full parts warranty for five year from project substantial completion acceptance by owner, whichever occurs first.
- C. Contractor to certify and provide warranty service within 4 hours to each site by factory trained personnel once informed by the owner of a problem.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Trane model ACR
- B. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid. Equal system must have screw compressor and meet the specification including all scheduled performance.

- C. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 CHILLER DESCRIPTION

- A. The contractor shall furnish and install air-cooled water chiller with screw compressors and skid mounted pumping packages as shown as scheduled on the contract documents.
- B. The chillers and pumping packages shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.3 CHILLER OPERATION

- A. Chiller shall be capable of starting up with 95°F (35°C) entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 108°F (52°C)
- B. Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive mode. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.
- C. Rapid Restart™ after power restoration. The Chiller shall be capable of starting in 45 seconds.

2.4 COMPRESSORS

- A. Construct chiller using semi-hermetic, variable speed drive, helical rotary screw compressor per circuit.
- B. Provide compressor motor that is suction gas cooled with robust construction and system design protection.
- C. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.
- D. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.
- E. Provide compressor with automatic capacity reduction equipment consisting of capacity control via variable speed drive and slide valve. Compressor must start unloaded for soft start on motors.
- F. Chiller shall be capable of operation down to 25% load without hot gas bypass.

2.5 EVAPORATOR

- A. The evaporator shall be designed, tested, and stamped in accordance with ASME code for a refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig.
- B. Insulate the evaporator with a minimum of 0.75 inch (K=0.28) UV rated insulation. The insulation shall be field installed, the additional money to cover material and installation costs in the field should be included in the bid.
- C. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets.
- D. Provide ability to remove evaporator tubes from the heat exchanger.
- E. Evaporator shall have cleanable tubes
- F. Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.
- G. Water connections shall be grooved pipe.
- H. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

2.6 FANS

- A. Low sound fans shall be balanced and direct driven.
- B. All condenser fan TEAO motors have permanently lubricated ball bearings and external overload protection.
- C. Each condenser fans shall have an integrated drives to provide variable speed for optimized efficiency and lower part load sound.

2.7 CONDENSER

- A. Construct condenser coils of aluminum fins mechanically bonded to internally finned tube. The condenser coils shall have an integral subcooling circuit and shall be designed for 350 psig or higher working pressure. Leak tested at 1.1 times working pressure.
- B. Condenser coils shall be made of a single material to avoid galvanic corrosion due to dissimilar metals. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 350 psig working pressure. Leak tested at 1.1 times working pressure.

- C. Condenser coils shall be transverse design. If coils are not transverse design, provide coil protection for shipping.
- D. The condenser coils shall have epoxy coating and shall withstand 10,000 hours in a salt-spray fog test in accordance with ASTM B117.
- E. Enclosures/chiller construction
- F. Unit panels, structural elements and control boxes are constructed of galvanized steel and mounted on a bolted galvanized steel base. Unit panels, control boxes and the structural base are finished with a baked on powder paint.
- G. Control panel doors shall have door stays.
- H. Mount starters and Terminal Blocks in a UL 1995 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.
- I. The coating or paint system shall withstand 10,000 hours in a salt-spray fog test in accordance with ASTM B117.

2.8 CHILLER MOUNTED ADAPTIVE FREQUENCY DRIVE (AFD)

- A. The water chiller shall be furnished with a fluid cooled 12 pulse minimum Adaptive Frequency Drive (AFD) as shown on the drawings.
- B. The AFD efficiency shall be 97% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.96 at all loads for AFD. All other starters shall have a minimum displacement power factor of 0.85.
- C. Power semi-conductor and capacitor cooling shall be from a liquid or air cooled heatsink.
- D. A control power transformer shall be factory-installed and factory-wired to provide unit control power.
- E. Unit wiring shall run in liquid-tight conduit.
- F. Unit to be provided parallel piped with shut off valve supply and return cooling water filters to allow unit operation while one filter is being changed.

2.9 REFRIGERANT CIRCUIT

- A. All chillers shall have 2 refrigeration circuits, with 1 or 2 compressor on each circuit.

B. Provide for refrigerant circuit:

1. Liquid line shutoff valve
2. Suction service valve
3. Discharge service valve
4. Filter (replaceable core type)
5. Liquid line sight glass.
6. Electronic expansion valve sized for maximum operating pressure
7. Charging valve
8. Discharge and oil line check valves
9. High side pressure relief valve
10. Integrated oil loss sensor

2.10 CONTROLS

- A. A color, touch sensitive liquid crystal display (LCD) shall be unit mounted and a minimum of 7" diagonal. Graphical Icons provide links to sub menus on the subsystems operations.
- B. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, and motor information as well as associated diagnostics.
- C. The chiller control panel shall provide password protection of all setpoints
- D. The controller shall have the ability to display all primary sub-system operational parameters on dedicated trending graphs. The operator must be able to create up to 6 additional custom trend graphs, choosing up to 10 unique parameters for each graph to trend log data parameters simultaneously over an adjustable period and frequency polling.
- E. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer.
- F. The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges:
 1. Run time.
 2. Number of starts.
 3. Current chiller operating mode.
 4. Chilled water set point and set point source.
 5. Electrical current limit set point and set point source.
 6. Entering and leaving evaporator water temperatures.
 7. Saturated evaporator and condenser refrigerant temperatures.
 8. Evaporator and condenser refrigerant pressure.
 9. Oil tank pressure.
 10. Intermediate oil pressure in the compressor.

11. Compressor motor current per phase.
 12. Compressor motor percent RLA.
 13. Compressor motor voltage per phase.
 14. Phase reversal/unbalance/single phasing and over/under voltage protection.
 15. Low chilled water temperature protection.
 16. High and low refrigerant pressure protection.
 17. Load limit functions (both current based or pulldown rate based) to limit compressor loading on high return water temperature.
 18. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize chiller efficiency.
 19. Display diagnostics.
 20. Oil pressure control based off of maintaining system differential pressure.
 21. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.
 22. Oil loss indication.
- G. Weatherproof control panel shall be mounted on chiller, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer.
- H. The chiller controller shall utilize a microprocessor that will automatically take action to prevent chiller shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
- I. Provide the following safety controls with indicating lights or diagnostic readouts.
1. Low chilled water temperature protection.
 2. High refrigerant pressure.
 3. Low oil flow protection.
 4. Loss of Oil diagnostic
 5. Loss of chilled water flow.
 6. Contact for remote emergency shutdown.
 7. Motor current overload.
 8. Phase reversal/unbalance/single phasing.
 9. Over/under voltage.
 10. Failure of water temperature sensor used by controller.
 11. Compressor status (on or off).
- J. Provide the following operating controls:
1. A variable method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start.
 2. Chilled water pump output relay that closes when the chiller is given a signal to start.
 3. Load limit functions to limit compressor loading on high return water temperature to prevent nuisance trip outs.

4. High condenser pressure limit controls that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
 5. Compressor current limit controls that unloads compressors to help prevent current overload nuisance trip outs.
 6. Low ambient lockout control with user adjustable setpoint.
 7. Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing chiller efficiency.
- K. Provide user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following features:
1. Leaving chilled water setpoint adjustment from touch panel input
 2. Entering and leaving chilled water temperature output
 3. Percent RLA output for each compressor
 4. Pressure output of condenser
 5. Pressure output of evaporator
 6. Ambient temperature output
 7. Voltage output
 8. Current limit setpoint adjustment from LCD input.
- L. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- M. The chiller controls shall be provided with communications interface compatible with campus Building Automation System BAS. All points shall be available through the interface. All set points shall be adjustable through interface. All alarms shall be configured to automatically pass through the interface to the BAS.
- 2.11 SOUND
- A. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels, per AHRI 370. A-weighted sound pressure at 30 feet should be provided at 100%, 75%, 50% and 25% load points to identify the full operational noise envelope.
 - B. If manufacturer cannot meet the noise levels, sound attenuation devices and/or barrier walls must be installed to meet this performance level.
 - C. Chiller shall ship with a muffler on each rotary screw compressor and very low noise condenser fans to meet the scheduled sound levels. If chiller does not meet sound levels, chiller manufacturer shall provide additional attenuation features.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's requirements.
 - 1. Level the chiller using the base rail as a reference. The chiller must be level within 1/2" in over the entire length and width. Use shims as necessary to level the chiller.

3.2 SERVICE AND START-UP

- A. Startup - Provide all labor and materials to perform startup. Startup shall be performed by a factory-trained technician from the original equipment manufacturer (OEM). Technician shall confirm that equipment has been correctly installed and passes specification checklist prior to equipment becoming operational and covered under OEM warranty. This shall be done in strict accordance with manufacturer's specifications and requirements. Third-party service agencies are not permitted.
- B. A start-up log shall be furnished by the factory approved start-up technician to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.
- C. Chiller manufacturers shall maintain service capabilities no more than 4 hours travel from the jobsite.
- D. Provide local service agent with direct access to factory support on equipment.
- E. The service provider shall employ a minimum of 2 full time, competent HVAC and automation system servicepersons on staff, whose office in which they operate from is within 4 hours of the job site.
- F. As an alternate provide a 6-year labor and parts service agreement. Service agreement shall be executed in 2-year increments with owner option to continue for the next two years or cancel the contract. Service contract will be paid for in two-year increments. Cost provided at bid shall be inclusive per 2-year increment for total of 6 year term with owner only guaranteeing first 2 years if executed. If owner chooses not to execute the remaining portion of the 6 years at any two year increment the contractor shall not be paid any additional compensation by owner.
- G. During the base 12 month warrantee period, a factory-trained technician from the original equipment manufacturer (OEM) shall perform quarterly on-site operating inspections to confirm the chiller's operational performance. The manufacturer shall provide the owner with a report describing the condition of the equipment, current operating log, any issues found needing to be addressed, and recommended corrective actions.

END OF SECTION 236423.13

SECTION 237313 - CENTRAL STATION DEDICATED OUTSIDE AIR - AIR HANDLER

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Applied Air Handling Units.

1.2 RELATED SECTIONS

- A. Section 230923 - Building Automation and Control Systems

1.3 REFERENCES

- A. AMCA Publication 99 - Standards Handbook.
- B. AMCA Publication 611 - Certified Ratings Program - Airflow Measurement Performance
- C. AMCA Standard 500-D - Laboratory Methods of Testing Dampers for Rating.
- D. ANSI/ABMA Standard 9 - Load Ratings and Fatigue Life for Ball Bearings.
- E. ANSI/AMCA Standard 204 - Balance Quality and Vibration Levels for Fans.
- F. ANSI/AMCA Standard 610 - Laboratory Methods of Testing Airflow Measuring Stations for Rating.
- G. ANSI/AHRI Standard 410 - Forced Circulation Air-Cooling and Air-Heating Coils.
- H. ANSI/AHRI Standard 430 - Central Station Air Handling Units.
- I. ANSI/AHRI Standard 1060 - Rating Air-To-Air Energy Recovery Ventilation Equipment
- J. ANSI/ASHRAE Standard 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- K. ANSI/ASHARE Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.
- L. ANSI/ASHARE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

- M. ANSI/NEMA MG 1 - Motors and Generators.
- N. ANSI/UL 900 - Standard for Safety Air Filter Units.
- O. AHRI Standard 260 - Sound rating of Ducted Air Moving and Conditioning Equipment.
- P. ASHRAE Standard 84 - Method of Testing Air-to-Air Heat Exchangers.
- Q. ASHRAE Standard 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.
- R. ASTM B117 - Standard Practice for Operation Salt Spray Apparatus.
- S. ASTM E477 - Standard Test Method for Measure Acoustical and Airflow Performance of Duct Liner
- T. NFPA 70 - National Electrical Code
- U. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
- V. UL 1995 - Standard for Safety Heating and Cooling Equipment

1.4 QUALITY ASSURANCE

- A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current AHRI Standard 410.
- B. Air handling units with fan sections utilizing single fans shall be rated and certified in accordance with AHRI Standard.
- C. Airflow monitoring station: Certify airflow measurement station performance in accordance with AMCA 611.
- D. ISO 9001 Certification.

1.5 SUBMITTALS

- A. No equipment shall be fabricated or delivered until the receipt of approved shop drawings from the Owner or Owner's approved representative.
- B. AHU manufacturer shall provide the following information with each shop drawing/product data submission:

1. Dimensioned arrangement drawings for each AHU including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
 2. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.
 3. Each component of the unit shall be identified, and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
 4. All performance data, including capacities and airside and waterside pressure drops, for components.
 5. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
 6. A filter schedule must be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, unit size, corresponding filter section location within the AHU, filter arrangement (e.g. angled/flat), filter depth, filter type (e.g. pleated media), MERV rating, and filter quantity and size.
 7. A schedule detailing necessary trap height shall be provided for each air handling unit. Schedule shall detail unit tag, unit size, appropriate trap schematic with recommended trap dimensions, and unit supplied base rail height. Contractor shall be responsible for additional trap height required for trapping and insulation beyond the unit supplied base rail height by adequate housekeeping pad.
 8. An electrical MCA - MOP schedule shall be provided for each electrical circuit to which field-power must be supplied. Schedule to detail unit tag, circuit description, voltage/phase/hertz, Minimum Circuit Ampacity (MCA), and calculated Maximum Overcurrent Protection (MOP).
 9. Sound data shall be provided using AHRI 260 test methods. Unit discharge, inlet, and radiated sound power levels in dB shall be provided for 63, 125, 250, 500, 1000, 2000, 4000 and 8000Hz.
- C. The AHU manufacturer shall provide appropriate sets of submittals as referenced in the General Conditions and shall submit to the Owner electronic copies of the IOM.
- D. The AHU manufacturer shall list any exceptions to the specification.

1.6 REGULATOR REQUIREMENTS

A. Agency Listings/Certifications

1. Unit shall be manufactured to conform to UL 1995 and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to the unit. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense, provide for a field inspection by a UL/CUL or ETL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the owner.

2. Air handling units with multiple direct drive plenum fans, or direct drive plenum fans incorporated with ECM style motors are outside the scope of AHRI 430. These fans however are rated in accordance with AHRI 430.
3. Certify air handling units in accordance with AHRI Standard 430. Units shall be provided with certification label affixed to the unit. If air handling units are not certified or fans are not rated in accordance with AHRI Standard 430 contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.
4. Certify air handling coils in accordance with AHRI Standard 410. Units shall be provided with certification label affixed to the unit. If air handling coils are not certified in accordance with AHRI Standard 410, contractor shall be responsible for expenses associated with testing of coils after installation to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs for field rigging, lifting and final placement of AHU section(s). AHU's less than 100-inches wide shall allow for forklift transport and maneuverability on the jobsite.
- C. Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.
- D. Installing contractor shall be responsible for storing AHU in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.8 START-UP AND OPERATING REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.9 WARRANTY

- A. Provide a full parts and labor warranty for two year from project substantial completion acceptance by owner, whichever occurs first.
- B. Provide a full parts warranty for five year from project substantial completion acceptance by owner, whichever occurs first.
- C. Contractor to certify and provide warranty service within 4 hours to each site by factory trained personnel once informed by the owner of a problem.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. Trane Performance Climate Changer
- B. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid. Equal system must have screw compressor and meet the specification including all scheduled performance.
- C. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 GENERAL

- A. Unit layout and configuration shall be as defined in project plans and schedule.
- B. Manufacturer to provide a full perimeter 8” integral base frame for either ceiling suspension of units or to support and raise all sections of the unit for proper trapping. Base frame will either be bolted construction. Contractor will be responsible for providing a housekeeping pad when unit base frame is not of sufficient height to properly trap unit. Unit base frames not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel. Unit base height to be included in total height required for proper trap height.

2.3 UNIT CASING

- A. Unit manufacturer shall ship unit in segments as specified by the contractor for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall

not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

- B. Leakage rate and/or casing pressure rating can be used as spec hooks. York can only claim to Class 10 leakage rate without factory calc checks. McQuay only claim to Class 14 (0.5 cfm/ft² @ 7.5") for Vision, or Class 7 for Vision Plus. Carrier does not specify air leakage rates for the Aero AHUs. TOPSS will calculate leakage for each selected air handling unit.
- C. Casing performance - Casing air leakage shall not exceed leak class 6 (CL = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft² of casing surface area) = CL X P^{0.65}.
- D. Air leakage shall be determined at a casing static pressure of 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.
- E. Under 55F supply air temperature and design conditions on the exterior of the unit of 81F dry bulb and 73F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.
- F. Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8-inch w.g., whichever is less, and shall not exceed 0.0042 per inch of panel span (L/240).
- G. Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042 per inch of panel span.
- H. Unit casing panels shall be 2-inch double-wall construction, with solid galvanized exterior and solid 316 stainless steel interior, to facilitate cleaning of unit interior.
- I. Unit casing panels (roof, walls, floor) and doors shall be provided with a minimum thermal resistance (R-value) of 13 Hr*Ft²*°F/BTU.
- J. Unit casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

- K. Casing panel inner liners must not extend to the exterior of the unit or contact the exterior frame. A mid-span, no-through-metal, internal thermal break shall be provided for all unit casing panels.
- L. Access panels and/or access doors shall be provided in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
- M. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

2.4 OUTDOOR UNIT FEATURES

- A. Outdoor Casing Details - In addition to all other details specified within for air handling units, units that are installed outdoors shall also comply with the following -
 - 1. Outdoor air handling units shall have only single door handles for each door linking multiple latching points necessary to maintain the specified air leakage integrity of the unit and ease of maintenance.
 - 2. Unit Paint - External surfaces of all outdoor unit casings shall be prepared and painted with a minimum 1.5 mil thick water based polyurethane finish or equal. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 10,000 consecutive hours.
 - 3. Unit Base - Outdoor units shall have a welded base and steel cross members for structural rigidity and supports the full perimeter of the air handling unit. AHU panels must overhang the primary unit base such that no ledge exists for water to pool. The entire AHU perimeter shall be sealed for additional water management protection. A drain pan under the entire unit or sections shall not be an acceptable alternative to prevent water from entering the building space.
 - 4. Unit Roof - Outdoor unit roofs shall incorporate a standing seam on the exterior to ensure a rigid roof construction and prevent water infiltration. Roof assembly shall overhang all walls by 1.5-inch minimum to prevent sheeting from roof to side panels. Rain gutters shall also be provided over all doors to direct rain away from the door assembly. Outdoor roofs shall be sloped, not less than 0.125 inches per foot, for water drainage. Where outdoor units are shipped in multiple sections, provide standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by the installing contractor.
 - 5. Weather Hoods - Outside and exhaust air weather hoods shall be fabricated from the same material as the unit exterior. Hoods shall extend past the perimeter of the unit casing opening to ensure the hood does not obstruct the airflow path. Hoods shall be painted with the same paint requirements identified for the external casing herein.
 - a. Outside air inlet hoods for each outside damper shall be provided with a high performance moisture eliminator to prevent entrainment of water into the unit from outside air. Exhaust hoods shall be provided on exhaust air openings and shall include a bird screen.

- b. All hoods shall be sized for 100 percent of nominal damper capacities and with 316 stainless steel bird screens or similar protection to prevent nesting and entry into AHU inlet or exhaust paths.
- 6. Factory Supplied Roofcurb - Roof curbs shall be provided where indicated on the plans and shall be galvanized steel. Roof curb shall support the full perimeter of the air handling unit, including pipe chases. A 2" x 4" nominal wood nailing strip shall be supplied attached to the roof curb. Wood nailing strip shall be of #4 Spruce or #4 Yellow Pine. Roof curb shall include frame work necessary to support supply and return duct installation prior to unit placement. Roof curb shall be shipped loose for field installation prior to unit placement.
- 7. The AHU manufacturer shall provide external pipe cabinet assemblies. External pipe cabinets shall be factory assembled and shipped with the units for field mounting. Cabinet walls and doors shall be the same double-wall construction and exterior color/finish as the unit wall panels. Cabinet roofs shall be sloped away from the unit for water drainage.
- B. Outdoor units shall be approved to comply with the High Velocity Hurricane Zone of the Virgin Islands Building Code and Uniform Building Code 2018 edition in the Manufactured Buildings category. The rating, as detailed in the approved NOA submittal package for the product, shall apply to the full range of lengths, widths, and heights of outdoors units being proposed on the project. Each outdoor unit shall bear a permanent label with the manufacturer's name or logo, city, state, and the statement Product Control Approved.

2.5 ACCESS DOORS

- A. Access doors shall be 2-inch double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels.
- B. All doors downstream of the cooling coil shall be provided with a thermal break construction of door panel and door frame.
- C. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.
- D. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.
- E. Handle hardware shall be designed to prevent unintended closure.
- F. Access doors shall be hinged and removable without the use of specialized tools.
- G. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions. Hinges shall be constructed of stainless steel.

- H. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.
- I. All doors shall be a 60-inch high when sufficient unit height is available, or the maximum height allowed by the unit height.
- J. An optional shatterproof window shall be provided in access doors where indicated on the plans. Window shall either be single pane, or thermal dual pane, as defined on schedule. Window shall be capable of withstanding unit operating pressures and shall be safe for viewing UV-C lamps.
- K. Test ports shall be supplied in access doors as defined in the unit schedule to facilitate the field commissioning by the test and balance contractor. Test ports shall not compromise the ASHRAE leakage class of the unit.

2.6 PRIMARY DRAIN PANS

- A. All cooling coil sections shall be provided with an insulated, double-wall, 316 stainless steel drain pan.
- B. The drain pan shall be designed in accordance with ASHRAE 62.1 being of sufficient size to collect all condensation produced from the coil and sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer's requirements. See section 2.07, paragraph F through H for specifications on intermediate drain pans between cooling coils.
- C. The outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
- D. All drain pan threaded connections shall be visible external to the unit. Threaded connections under the unit floor shall not be accepted.
- E. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2-inch beyond the base to ensure adequate room for field piping of condensate traps.
- F. The installing contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.
- G. Coil support members inside the drain pan shall be of the same material as the drain pan and coil casing.
- H. If drain pans are required for heating coils, access sections, or mixing sections they will be indicated in the plans.

2.7 FANS

- A. Fan sections shall have a minimum of one hinged and latched access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.
- B. Provide fans of type scheduled and high efficiency class for variable frequency drive operation. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans that are selected with inverter balancing shall first be dynamically balanced at design RPM. The fans then will be checked in the factory from 25% to 100% of design RPM to insure they are operating within vibration tolerance specifications, and that there are no resonant frequency issues throughout this operating range. Inverter balancing that requires lockout frequencies inputted into a variable frequency drive to in order to bypass resonant frequencies shall not be acceptable. If supplied in this manner by the unit manufacturer, the contractor will be responsible for rebalancing in the field after unit installation. Fans selected with inverter balancing shall have a maintenance free, circumferential conductive micro fiber shaft grounding ring installed on the fan motor to discharge shaft currents to ground.
- C. Fans shall be Direct drive plenum fans provided with ECM motors shall be a nine-blade, single width, single inlet fan with high efficiency welded -aluminum impeller that is dynamically balanced as an assembly.
 - 1. Fan shall be maintenance free throughout its operating life
 - 2. Fans shall be balanced to a G6.3 per AMCA 204. No vibration isolation base is necessary
 - 3. Access to motor and fan assembly though hinged access door must be provided. Access door shall be sized for removal of entire motor and fan assembly.
 - 4. Motor shall contain integrated PID controller and accept a 0-10VDC input signal for variable speed control.
 - 5. Motorized impeller fans shall be rated in accordance with AHRI Standard 430.6. Motorized impeller fan section shall include expanded metal door guard(s) supplied on the access door(s) to the fan. Door guard is intended to deter unauthorized entry and incidental contact with rotating components.
- D. Fan airflow measurement systems shall be provided as indicated on the schedule and drawings to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +/- 5 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with selectable 4-20 mA or 2-10 VDC output. Signal shall be proportional to air velocity.

- E. Each direct drive fan in a multiple-fan array shall be provided with integral back flow prevention: a backdraft damper that prohibits recirculation of air in the event a fan or multiple fans become disabled. Dampers are tested and rated based on AMCA Standard 500. Dampers to be heavy duty type capable of a maximum back pressure that exceeds the design total static pressure with minimal leakage. The dampers should have a minimal total effect on airflow performance both pressure drop when open and system effect on the fan. The damper blades and frame shall be extruded aluminum with blade edge seals locked into the blade edge. Adhesive type seals are unacceptable. AHU manufacturer responsible for providing proper spacing upstream of dampers to ensure full, uniform airflow through upstream components. For units where the damper(s) are supplied at the jobsite, the installing contractor shall contract a certified TAB contractor to verify uniform airflow thru upstream components.
- F. MOTORS AND DRIVES
 - 1. All motors and drives shall be factory-installed and run tested.
 - 2. Motors shall meet or exceed all NEMA Standards Publication MG 1 - 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.
 - 3. Fan Motors shall be heavy duty, open drip-proof operable at 460 volts, 60Hz, 3-phase. If applicable, motor efficiency shall meet or exceed NEMA Premium efficiencies.
 - 4. Direct driven fans utilizing integral frame motors shall use 2-pole (3600 rpm), 4-pole (1800 rpm) or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation capable to operate continuously at 104 deg F (40 deg C) without tripping overloads.
 - 5. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

2.8 COILS

- A. Coils section header end panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.
- B. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
- C. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- D. Construct coil casings of 316 stainless steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

- E. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
- F. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the sections primary drain pan, 316 stainless steel.
- G. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.
- H. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.
- I. Coil shall have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges. Corrosion durability shall be confirmed through testing to no less than 10,000 hours salt spray per ASTM B117.
- J. Hydronic Coils
 - 1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.
 - 2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.
 - 3. Headers shall be constructed of round copper pipe or cast iron.
 - 4. Tubes shall be 1/2-inch .016 copper, with copper fins.
 - 5. Hydronic coils shall be supplied with factory installed drain and vent piping to the unit exterior.
- K. Integral Face and Bypass
 - 1. Integral face and bypass coils shall be provided as indicated on the schedule and drawings. Coils shall meet performance as defined on the schedule. Coils shall consist of a built-in series of finned heating, and bypass areas, with mechanically interlocked dampers. Coils to be constructed of 14-gage galvanized steel, with fins shall be no less than .010-inch thick aluminum, and tubing with minimum .035-inch thick copper tubing. Coils shall be certified to, and bear the AHRI 410 Standard label.
 - 2. Dampers shall be arranged to completely enclose and isolate heating elements. Coils shall include mixing baffles to minimize downstream mixing distance to 24-inches. At minimum

distance, leaving air temperature shall vary no more than +/- 5 deg F from the average leaving air temperature.

3. Manufacturer shall extend coil connections on horizontal-tube coils through the unit casing wall to facilitate piping. Coil connection penetrations through unit casing shall be provided by unit manufacturer on vertical-tube coils. Installing contractor shall be responsible for providing flexible connector on return header, and supply/return piping through unit casing wall.

2.9 FILTERS

- A. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have side access filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement. Filters to be of size, and quantity needed to maximize filter face area of each particular unit size.
- B. Filter type, MERV rating, and arrangement shall be provided as defined in project plans and schedule
- C. Manufacturer shall provide one set of startup filters.
- D. Each filter section shall be provided with a factory-installed, flush-mounted Dwyer dial-type differential pressure gauge piped to both sides of the filter to indicate status. Gauge shall maintain a +/- 5 percent accuracy within operating temperature limits of -20°F to 120°F. Filter sections consisting of pre- and post-filters shall have a gauge for each.

2.10 DAMPERS

- A. All dampers, with the exception of external bypass and multizones (if scheduled), shall be internally mounted. Dampers shall be premium ultra-low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 3 CFM/square foot at two inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.
- B. Airflow measuring stations shall be provided and located in the outside and/or return air paths as indicated on the schedule and plans to measure airflow. Airflow measuring stations shall be tested per AMCA Standard 611 and licensed to bear the AMCA Ratings Seal for airflow measurement performance. Integral control damper blades shall be provided as galvanized steel and housed in

a galvanized steel frame. Leakage rate shall not exceed 4 CFM/square foot at two inch water gauge complying with ASHRAE 90.1 maximum damper leakage.

1. The airflow measurement station shall measure up to 100 percent of the total outside air and/or return air. The airflow measurement station shall be capable of measuring down to 300 fpm. The airflow measuring device shall adjust for temperature variations. Output shall be provided from the station as a 2-10 VDC signal. Signal shall be proportional to air velocity. The accuracy of the measuring station shall be no greater than +/- 5 percent. Airflow measuring stations shall be mounted on the AHU interior.
2. The installing contractor shall provide duct-mounted pleated media MERV 8 filtration upstream of airflow monitoring stations requiring air straightening vanes to prevent blockage of vanes. A filter access door shall be provided for filter replacement that does not degrade the specified duct leakage class. Duct-mounted filtration section with access door for filter removal shall be tested for compliance to specified duct leakage class on the schedule and plans.

2.11 ACCESS SECTIONS

- A. Access sections shall be provided where indicated in the schedule and plans to allow additional access for inspection, cleaning, and maintenance of unit components. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be provided in the AHU manufacturer's maintenance manual. Access section doors shall be constructed per Section 2.04.

2.12 AIR MIXER/BLENDER SECTION

- A. Air mixers (blenders) shall be provided and located as indicated on the schedule and drawings. Mixers shall incorporate fixed blades, with no moving parts. Mixer panels shall be sized and installed in the unit with adequate distances upstream and downstream, based on the manufacturers cataloged performance, to ensure a minimum mixing effectiveness of 70% at 25% outside air, at one mixer diameter downstream of the mixer.

2.13 EXTERNAL FACE AND BYPASS SECTION

- A. Dampers shall be provided as indicated on the schedule and plans to divert airflow around the coil external to the air handling unit. The air handling unit shall include pre-engineered openings for re-entry into the unit casing (fan, access, or blank section). Dampers shall be low leak and opposed blade arrangement. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at two inch water gauge. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.

2.14 SERVICE SECTION

- A. On outdoor units, manufacturer shall supply a service section as defined on the schedule. Service section shall be of sufficient length for either storage of service parts or for installation of field supplied components. Section shall include either door(s) on one or both side of the section or on the end of the section. An internal wall shall be supplied on the section to partition and block the section from the unit airflow.

2.15 INTERNAL FACE AND BYPASS SECTION

- A. Dampers shall be provided as indicated on the schedule and plans to divert airflow around the coil internally within the air handling unit. Dampers shall be low leak and opposed blade arrangement. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at two inch water gauge. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.

2.16 As an Alternate Provide ULTRAVIOLET (UV-C) LIGHTS

- A. UV-C light fixtures and lamps shall be provided by the air handler manufacturer. The UV-C fixtures shall be factory-assembled and tested in the air handler. Field-installed fixtures shall not be allowed.
- B. Design of the UV-C light array shall assure that the UV-C energy striking the intended coil and drain pan surfaces shall not be less than 550 microwatts per square centimeter and provide not less than 99 percent surface disinfection efficiency. The minimum intensity at any point on the surface plane of the coil must exceed 100 microwatts per square centimeter. Energy consumption at the design intensity shall be no more than 10 watts for each square foot of treated, cross sectional plane.
- C. Lamps and Fixtures
 - 1. UV-C lamps and fixtures shall be positioned to provide an equal distribution of UV-C energy and to minimize shadowed areas. The fixture assembly shall be designed and installed such that the sum of the lamp arc lengths in a row is a minimum of 90% of the irradiated surface's total width. The lamps shall not produce ozone.
 - 2. Each lamp shall be high-output, hot cathode, T8 diameter, medium bi-pin type that produces UVGI of 254 nanometers. Lamps shall contain no more than 5.5 milligrams of mercury while producing the specified UV-C output when installed in an environment with 500 fpm air velocity and subjected to temperatures of 55-135 degrees F. Lamp life shall be 9,000 hours minimum with no more than a 20 percent loss of output after two years of continuous use.
 - 3. Fixtures shall meet the UL drip-proof design criteria and be constructed of stainless steel to resist corrosion. Racks for fixtures shall be constructed of galvanized steel as AHU

interior. Fixtures shall have been independently tested and recognized by UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards 153, 1598 and 1995.

D. Protection of Polymeric Materials

1. All polymeric materials that come into direct or indirect (reflected) contact with UV-C light shall be tested and certified as UV-C tolerant. Any polymeric material in direct or indirect contact with UV-C light not certified as UV-C tolerant shall be completely shielded from the UV-C light using a certified UV-C tolerant material such as metal. UV-C tolerance is defined as being capable of performing its intended duty for a minimum of 20 years.

E. Safety

1. Access doors shall be provided at the location of each UV-C light as indicated on the plans and schedule. All sections of the air handler with access doors where the UV-C lights may pose a risk for direct exposure shall have a mechanical interlock switch that disconnects power to the lights when the door is opened.
2. In addition to the mechanical interlock switch, each unit shall be equipped with an externally mounted on-off/disconnect/shut off switch that disconnects power to the UV-C lights. The switch shall be equipped with a lock-out/tag-out to prevent unwanted operation of the UV-C lights.
3. A view port with cover shall be provided in each UV section to allow viewing of the UV-C light array confirming operation. The view port and other AHU windows shall be treated to assure the UV-C energy emitted through it is below the threshold limits specified by NIOSH and ACGIH.
4. Units shall have a safety warning label applied to the exterior of each section containing UV-C lights.
5. Complete safety, maintenance and servicing instructions for the UV-C lights and fixtures shall be incorporated into the air handler manufacturer's standard installation, operating and maintenance manuals.

2.17 DISCHARGE PLENUM SECTIONS

- A. Plenums shall be provided as indicated in the schedule and plans to efficiently turn air and provide acoustical attenuation. Discharge plenum opening types and sizes shall be scaled to meet pressure drop requirements scheduled and align with duct takeoffs.
- B. Discharge plenum panels shall include an acoustical liner where indicated in the schedule and plans to meet acoustical requirements. The liner shall be fabricated from perforated material to prevent corrosion and designed to completely encapsulate fiberglass insulation. The perforation spacing and hole size shall be such as to prevent insulation breakaway, flake off, or delamination when tested at 9000 fpm, in accordance with UL 181 or ASTM C1071. Insulation material must be resistant to fungi in accordance with ASTM C1338.

2.18 TOTAL ENERGY RECOVERY WHEEL SECTION

- A. Total energy recovery wheels shall be provided as indicated on the schedule and drawings. Wheels shall be integral parts of the AHUs and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable. Mixed air units with economizing shall be constructed with internal bypass dampers such that the pressure drop across the wheel does not increase during economizing. External bypass and multiple duct connections are not acceptable.
- B. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.
- C. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The adsorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable.
- D. Wheel drive motor shall be provided mounted in the cassette frame. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioner. On units that require drive belt tensioner for the wheel belt/motor assembly, the unit manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings.
- E. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.
- F. Access doors shall be provided for the removal of wheel segments. Doors shall be located to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal.

- G. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.
- H. Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.
- I. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.
- J. Access doors shall be provided on all air entering and air leaving sides of wheel to allow for wheel maintenance, belt or motor removal. Access doors shall be constructed per Section 2.04.

2.19 AIR TO AIR HEAT PIPE ENERGY RECOVERY

- A. Provide Heat Pipe air to air closed loop energy recovery system as indicated drawings and schedules.
 - 1. Air Handler(s) shall be equipped with Energy Recovery Heat Pipes supplied by Heat Pipe Technology, Inc. to transfer heat from the exhaust air to the incoming supply air. Supply and Exhaust heat pipe sections are separated horizontally on the same level or separated horizontally and vertically as specified below
 - a. Energy recovery heat pipes shall be tested and certified to AHRI standard 1060. Performance printouts as well as the product itself to carry AHRI 1060 compliance logo. Documents showing testing in accordance with AHRI 1060, but not certified by AHRI, will not be acceptable. Any deviation from the specifications must be approved by the engineer no less than ten days prior to the project bid date. No consideration of alternates will be given after that time. Heat pipes shall be completely manufactured and fully assembled at the manufacturer's facility by factory personnel.
 - 2. CONSTRUCTION
 - a. Coil tubes shall be oriented vertical and the fins run horizontal. Each two rows shall be manifolded together into one liquid line at bottom and one vapor line at top and constitute one circuit. Lines shall be sized according to the performance

requirements of the circuit. Each heat pipe section shall be installed level and connected to the other section by two horizontal copper lines, for each circuit, one for liquid and one for vapor. ☐ Extended drain pans (by others) to be provided downstream of supply as well as exhaust sections, or ☐ Moisture eliminators shall be installed immediately downstream of the supply and exhaust sections of the heat pipe to capture condensate that may spit from the heat pipe fins. Condensate shall drain out of the bottom into a drain pan (supplied by others). The moisture eliminator shall be capable of capturing at least 99.75% of condensate when the coil is producing condensate at a rate of 0 to 15 lbswater/sqft/hour and coil airflow is ≤ 700 SFPM. Static pressure loss will not exceed 0.18 in.wg. at 500 SFPM.

- b. The moisture eliminator blades will be constructed of ABS plastic and meet UL Standard 94 classification V-0, which requires blades to self-extinguish within 10 seconds. It will incorporate an additive that protects against fungal and bacterial deterioration to provide long-term protection against fungal and bacterial attack and help prevent surface growth, permanent staining, embrittlement and premature product failure. The anti-fungal and anti-bacterial additive shall be mixed with the polymer and shall not be a coating, which could wear off over time.

3. OPTIONAL CONTROL VALVE FEATURE

- a. All or a portion [SPECIFY] of the Heat Pipe circuits shall be equipped with modulating control valves to control the operation of the Heat Pipe circuits. Each circuit shall have one modulating step motor valve in the lower liquid line in an accessible location. Each valve will connect to a control printed circuit board in a NEMA 12 enclosure that contains the number of control boards to control all valves in the system and the appropriate power conversion. The customer supplied electrical power to the control panel power supply transformer shall be as scheduled for the unit and shall be factory wired for single point power.
- b. The Building Automation System (BAS) shall provide the sensors necessary for determination of heat pipe modulation operation and the BAS computer shall be programmed to send the operating control signals to the modulating valves' control boards as required for correct system operation. The control signal shall go through a BAS interface installed near the heat pipe NEMA box. The BAS control signal provided shall be 0 to 10 volt DC or ☐ 4-20 mA.
- c. All additional wiring shall be provided and installed by others. With all control valves open, the energy recovery heat pipe assembly will operate at full capacity. Modulating one valve closed restricts the liquid return flow and reduces the heat transferred by the heat pipe until closing the valve shuts off that circuit. Frost control, if needed, is accomplished by closing or shutting off one or more circuits. Economizer operation is also accomplished by shutting off circuits to achieve desired heat transfer.

4. HEAT PIPES

- a. The Heat Pipe supplier shall have a minimum of 5 years of experience designing, manufacturing, and installing Heat Pipes specifically for split energy recovery applications. Heat pipes must be manufactured and assembled at the heat pipe supplier's own facility by supplier's own staff.
- b. The tubes shall be copper only, of specific design for Heat Pipe application, permanently expanded onto the fin collar to form a firm, rigid, and complete pressure contact at all operating conditions. Aluminum tubes will not be allowed.
- c. The fin surface shall be continuous plate type copper fins of specific design to produce maximum heat transfer efficiency for Heat Pipe applications. Airside pressure loss shall be as given on the schedule, or otherwise specified. Fin density and the number of rows of tubes shall be as specified.
- d. The Heat Pipe modules shall have an optional protective coating of □E-Coat, phenolic, similar to Heresite. Heat pipes shall be dipped and completely submerged to insure full coverage of coating - spray coatings are not acceptable.
- e. Heat transfer fluid shall be classified as Safety Group A1 in ASHRAE Standard 34-2013.
- f. Heat Pipe capacities, entering and leaving dry and wet bulb temperatures, and face velocity shall be as specified.
- g. The Heat Pipes shall be installed as specified.
- h. Frames and mounting structure shall be minimum 16 gauge stainless steel.
- i. Heat Pipe interconnecting piping and circuitry shall be as specified by Heat Pipe Technology design. Each circuit shall be individually processed, charged, hermetically sealed, and tested.
- j. The heat pipe system shall be pressure tested on site under the supervision of the manufacturer's crew. Manufacturer's crew shall vacuum and charge the system. Vacuuming and charging by parties other than the manufacturer's own crew shall not be acceptable.
- k. Scheduled effectiveness or heat recovery shall be met at a minimum and total pressure drop shall not be exceeded. The resulting Recovery Efficiency Ratio, or RER, shall therefore be met at a minimum.
- l. The Heat Pipes shall be ETL listed to UL standard 207 and CSA C22.2.140.3.
- m. Heat pipe configuration shall be as shown on the drawings and schedules.

2.20 MARINE LIGHTS

- A. Marine lights shall be provided throughout AHUs as indicated on the schedule and plans. Lights shall be instant-on, light-emitting diode (LED) type to minimize amperage draw and shall produce lumens equivalent to a minimum 75W incandescent bulb (1200 lumens). LED lighting shall provide instant-on, white light and have a minimum 50,000 hr life.
- B. Light fixture shall be weather-resistant, enclosed and gasketed to prevent water and dust intrusion.

- C. Fixtures shall be designed for flexible positioning during maintenance and service activities for best possible location providing full light on work surface of interest and not being blocked by technician.
- D. All lights on a unit shall be wired in the factory to a single on-off switch.
- E. Installing contractor shall be responsible for providing 115V supply to the factory-mounted marine light circuit (unless single-point power is specified to be provided by AHU manufacturer).

2.21 CONVENIENCE OUTLETS

- A. A 15-amp, 115V GFCI convenience outlet shall be provided by the AHU manufacturer. The outlet shall be separate from the load side of the equipment per NEC requirements. Installing contractor shall be responsible for providing 115V supply to the factory-mounted GFCI outlet circuit per NEC (even when single-point power is specified to be provided by AHU manufacturer).

2.22 12 PULSE VARIABLE FREQUENCY DRIVES (VFDS)

- A. 12 Pulse Variable frequency drives shall be provided, mounted and wired by the AHU manufacturer as indicated on the schedule and drawings. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. The VFDS shall be UL listed. The listing shall allow mounting in plenum or other air handling compartments.
- B. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.
- C. With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDS utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.
- D. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- E. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL 508 certified for the building and assembly of option panels. Assembly of separate panels with options by a third-party is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel.

- F. The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3% impedance line reactor.
- G. The VFDs full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- H. The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- I. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- J. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- K. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- L. Galvanic and/or optical isolation shall be provided between the VFDs power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
- M. The VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
- N. Protective Features
 - 1. Protection shall be provided against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VFD overtemperature and motor overtemperature. The VFD shall display all faults as words. Codes are not acceptable.
 - 2. The VFD shall be protected from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD shall continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units, 313 V AC for 460 volt units, and 394 volts for 600 volts units.
 - 3. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.

4. The VFD package shall include semi-conductor rated input fuses to protect power components.
5. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise the AHU manufacturer shall ensure that inverter rated motors are supplied.
6. The VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
7. The VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
8. The VFD shall catch a rotating motor operating forward or reverse up to full speed.
9. The VFD shall be rated for 100,000 amp interrupting capacity (AIC).
10. The VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD shall identify which of the output phases is low or lost.
11. The VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt units, 539 V AC on 460 volt units, and 690 volts on 600 volt units.

O. Interface Features

1. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference. On units with bypass, a VFD/Off/Bypass selector switch shall be provided.
2. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.
3. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.
4. A lockable, alphanumeric backlit display keypad shall be provided. The keypad shall be remotely mountable up to 10 feet away using standard 9-pin cable.
5. The keypads for all sizes of VFDs shall be identical and interchangeable.
6. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFDs keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
7. The display shall be programmable to display in English, Spanish and French at a minimum.
8. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
9. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.
10. The VFD shall include a standard EIA-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2 Metasys or Siemens FLN system at no additional cost to the owner. The connection shall be software selectable by the user.
11. At a minimum, the following points shall be controlled and/or accessible:

- a. VFD Start/Stop
- b. Speed reference
- c. Fault diagnostics
- d. Meter points

(i)	Motor power in HP
(ii)	Motor power in kW
(iii)	Motor kW-hr
(iv)	Motor current
(v)	Motor voltage
(vi)	Hours run
(vii)	2 feedback signals
(viii)	DC link voltage
(ix)	Thermal load on motor
(x)	Thermal load on VFD
(xi)	Heatsink temperature

- 12. Four additional Form C 230 volt programmable relays shall be available for field installation within the VFD
- 13. BACnet communication compatible with and fully integrated into the site Building Automation System shall be available for factory installation within the VFD.
- 14. Two set-point control interfaces (PID control) shall be standard in the unit. The VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
- 15. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
- 16. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.
- 17. Sleep mode shall be provided to automatically stop the VFD when its speed drops below set ζ sleep ζ level for a specified time. The VFD shall automatically restart when the speed command exceeds the set ζ wake ζ level.
- 18. The sleep mode shall be functional in both follower mode and PID mode.
- 19. A run permissive circuit shall be provided to accept a ζ system ready ζ signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
- 20. The following displays shall be accessible from the control panel in actual units: Reference Signal Value, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and unit CFM.
- 21. The display shall be programmed to read in inches of water column (in-wg).
- 22. The VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- 23. If the temperature of the VFDs heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink

continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFDs heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.

24. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.
25. The VFD shall store in memory the last 10 faults and related operational data.
26. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
27. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.
28. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
29. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24V DC status indication.
30. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

P. Adjustments

1. The VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.
2. A minimum of sixteen preset speeds shall be provided.
3. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
4. Four current limit settings shall be provided.
5. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: undervoltage, overvoltage, current limit and inverter overload.
6. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
7. An automatic ¿on delay¿ shall be selectable from 0 to 120 seconds.

Q. Service Conditions

1. VFDs shall provide full output in an ambient temperature from -10 to 50°C (14 to 104°F).
2. VFDs shall provide full output in a relative humidity from 0 to 95%, non-condensing.
3. VFDs shall provide full output up to 3,300 feet elevation without derating.
4. VFDs shall provide full output with an AC line voltage variation from -10 to +10% of nominal voltage.
5. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

R. Warranty

1. The VFD shall be warranted by the manufacturer for a period of 36 months from owner acceptance of substantial completion. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory-authorized on-site service.

2.23 Factory-Installed Motor Wire Termination, VFD, and Combination Starter/Disconnect Enclosures

- A. VFDs shall be factory mounted on the drive side of the fan section. VFD may be mounted on the interior of the unit, accessible from the unit exterior through an access door, or on the casing exterior in a NEMA Type 1 enclosure for indoor units. If not mounted on the fan section due to NEC disconnect height limitations or serviceability constraints in the mechanical equipment room, VFD may be mounted in another location other than the fan.
- B. Any welds shall be properly finished with no rough edges. Enclosures shall house circuit breaker disconnects, bypass circuitry, Drive-OFF-Bypass switches, manual speed controls, and control transformers. VFDs and starter/disconnects shall have an external disconnect located on the outside of the access door.

2.24 VFD per Fan

- A. Multiple VFDs on a common panel, shall be provided for each fan array to provide redundancy in case of loss of function of one of the VFDs or motors. Individual VFD shall be sized based on motor FLA to reduce overall panel input current. In the event of a VFD failure, the remaining VFDs must be capable of compensating and maintaining normal fan array operation.
- B. VFD panel shall have a common disconnect that is accessible from the outside of the unit. Disconnect shall open input power to all VFDs simultaneously. Disconnect shall be lockable in the off position. Disconnect shall utilize circuit breaker to provide overcurrent and short circuit protection.
- C. VFD panel shall be provided with a common point connection for speed input signal, start/stop signal, fault status, and field interlock connection
- D. VFD panel shall be provided with a single point of field connection for field input power. Each VFD shall be supplied with independent input fusing, as required. Panel shall be provided with short circuit current of 65,000 amps RMS symmetrical.
- E. Externally mounted VFDs shall be provided with independent keypad.

2.25 Motor Overload Panel for Fan Arrays

- A. A motor overload panel provides a single unit mounted UL508A listed control panel with all fans in an array pre-wired to it, such that one properly sized VFD may be field connected with no additional provisions required for protection of the individual motors. The control panel enclosure will be mounted on the exterior of the fan section and will be NEMA type 1 for indoor units and NEMA type 4 for outdoor units. A single power distribution block shall be provided for connection of the field mounted VFD with one conductor per phase. An electronic motor overload protector with lockable manual isolation switch shall be provided for each motor in the array. Each motor in the array shall be independently grounded with a dedicated green conductor. A minimum of one open ground lug per fan plus one shall be provided for field use. Each motor overload protector shall be provided with an auxiliary contact and all auxiliary contacts will be wired in series to a terminal block for generic trip signaling. The panel will be rated for WYE power systems up to 600V.

2.26 Factory Wiring of Lights, VFDs, and Combination Starters/Disconnects

- A. VFDs shall be wired per NEC, UL, and NFPA 90A requirements. Units with factory-mounted controls shall also include power wiring from the VFD or starter/disconnect control transformer to the control system transformers. Units with VFDs and factory-mounted controls shall have a binary start-stop signal and an analog speed signal wired from the direct digital controller to the VFD.
- B. All power wiring for voltages greater than 24V and traveling through multiple unit sections shall be contained in an enclosed, metal, power-wiring raceway or EMT. Sections less than 6-inch in length may be contained in FMC.
- C. After mounting and wiring of VFDs, on the AHUs, trained factory personnel shall ensure proper operation of each VFD, through a thorough factory test. Testing shall include a Hypot test of unit wiring to ensure that no weaknesses exist in wiring or motor. Each VFD shall be energized and the fan run to ensure the VFD will operate throughout the usable range of the drive and that the fan rotation is correct. Each VFD with bypass shall also be tested in the bypass position to ensure the bypass is operational.
- D. For fan motors not supplied with a factory mounted and wired starter or VFD, the unit manufacturer shall supply a 4 X 4 NEMA 4 junction box on the exterior of the fan section(s) with wiring, prewired to the fan motor, to allow for ease of field installation of a starter or VFD.
- E. On units provided with factory mounted and wired supply fan starter or VFD and DDC controls, the manufacturer shall provide a single point of power. Line-to-24v transformers shall be provided with sufficient vA to power the unit mounted controller and factory installed control points.

2.27 Factory Testing

- A. A factory air leakage test shall be performed to verify the air handling unit conforms to the specified air leakage requirement. The entire unit shall be tested at specified total unit static as selected and specified from the TOPSS selection. Leakage shall be calculated by totaling all leakage either into or out of the unit casing. Leakage shall not exceed specified leakage amount. Air pressure and casing leakage shall be measured by a third party calibrated and certified apparatus. A written test report shall be prepared by the manufacturer and issued to the owner or owner representative.
- B. A factory unit deflection test shall be performed to verify the air handling unit does not exceed $L/240$ of the panel span at the specified total unit static as selected and specified from the TOPSS selection. A written test report shall be prepared by the manufacturer and issued to the owner or owner representative.
- C. The owner or designated representative shall witness the leakage and/or deflection test(s) at the factory. The owner will be notified a minimum of 10 days in advance of the testing to provide time to coordinate travel arrangements. Written test report(s) shall be prepared by the manufacturer and issued and presented to the owner or owner representative after testing.

PART 3 - EXECUTION

3.1 SHIPPING

- A. Paper copies of the IOM shall also be shipped with each AHU.
- B. The AHU manufacturer shall identify all shipments with the order number. Enough information shall be provided with each shipment to enable the Mechanical Contractor to confirm the receipt of units when they are received. For parts too small to mark individually, the AHU manufacturer shall place them in containers.
- C. To protect equipment during shipment and delivery, all indoor units shall be completely stretch or shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.
- D. After loading the equipment for shipment, the AHU manufacturer shall contact the shipping contact on the order and provide the name of the carrier, description of equipment, order number, shipping point, and date of shipment.

3.2 ON-SITE STORAGE

- A. If equipment is to be stored for a period of time prior to installation, the Mechanical Contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall

either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in a well-drained area. Covering units with plastic tarps shall not be acceptable.

3.3 FIELD EXAMINATION

- A. The Mechanical Contractor shall verify that the mechanical room and/or roof are ready to receive work and the opening dimensions are as indicated on the shop drawings and contract documents.
- B. The Mechanical Contractor shall verify that the proper power supply is available prior to starting of the fans.

3.4 INSTALLATION

- A. The Mechanical Contractor shall be responsible to coordinate ALL of his installation requirements with the Owner and the Owner's selected Mechanical Contractor to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.
- B. The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.
- C. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU manufacturer's final inspection and start up:
 - 1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
 - 2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
 - 3. All water and steam piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
 - 4. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
 - 5. All power wiring, including motor starters and disconnects, serving the unit has been completed.
 - 6. All automatic temperature and safety controls have been completed.
 - 7. All dampers are fully operational.
 - 8. All shipping materials have been removed.
 - 9. All (clean) filter media has been installed in the units.

3.5 LEVELING

- A. The Mechanical Contractor shall level all unit sections in accordance with the unit manufacturer's instructions. The Mechanical Contractor shall provide and install all necessary permanent shim material to ensure individual sections and entire assembled units are level.

3.6 FINAL INSPECTION AND START UP SERVICE

- A. After the Mechanical Contractor has provided all water and steam piping connections, ductwork connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the Mechanical Contractor shall inspect the installation. The Mechanical Contractor shall then perform startup of the equipment.
- B. The Automatic Temperature Control (Building Direct Digital Control) Contractor shall be scheduled to be at the job site at the time of the equipment start up.
- C. The Mechanical Contractor, shall perform the following tests and services and submit a report outlining the results:
 - 1. Record date, time, and person(s) performing service.
 - 2. Lubricate all moving parts.
 - 3. Check all motor and starter power lugs and tighten as required.
 - 4. Verify all electrical power connections.
 - 5. Conduct a start up inspection per the AHU manufacturer's recommendations.
 - 6. Record fan motor voltage and amperage readings.
 - 7. Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.
 - 8. Check fan for excessive vibration.
 - 9. Remove all foreign loose material in ductwork leading to and from the fan and in the fan itself.
 - 10. Disengage all shipping fasteners on vibration isolation equipment.
 - 11. Check safety guards to insure they are properly secured.
 - 12. Secure all access doors to the fan, the unit and the ductwork.
 - 13. Switch electrical supply "on" and allow fan to reach full speed.
 - 14. Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.
 - 15. Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving chilled water temperatures and flow, steam pressures and flow, and outside air temperature.
 - 16. Check all control sequences.

END OF SECTION 237223

SECTION 238219 - TERMINAL HEATING & COOLING UNITS - BLOWER COIL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Blower coils

1. Air Handling Units - 0.8 square feet to 6.25 square feet of coil face area.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 230923 Enterprise Direct Digital Control and Campus Building Automation System.
- B. Section 16180 - Equipment Wiring Systems: Thermostats and control components.

1.3 RELATED SECTIONS

- A. Section 230923 Enterprise Direct Digital Control and Campus Building Automation System.

1.4 REFERENCES

- A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. UL 1995 - Heating and Cooling Equipment.
- D. NMFC item 180: Package Performance Testing in accordance with National Motor Freight Classification.
- E. AHRI 260-2001 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment.

1.5 QUALITY ASSURANCE

- A. Unit designed and tested in compliance with AHRI 430 air delivery ratings per AHRI 430-2014.
- B. Unit designed and tested in compliance with AHRI 260-2001.

1.6 SUBMITTALS

- A. Submit unit performance data including: capacity, nominal and operating performance.
- B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- C. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
- D. Provide fan curves with specified operating point clearly plotted.
- E. Submit data on electrical requirements. Include safety and start-up instructions.

1.7 REGULATORY REQUIREMENTS

- A. Unit shall be manufactured to conform to UL 1995 Standard and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to unit.
- B. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense provide for a field inspection by a UL/CUL representative to verify conformance. If necessary, contractor shall perform modifications to the unit(s) to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the Owner.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags on each section to indicate location and orientation in direction of airflow. Each section shall have lifting points to allow for field rigging and final placement of section.
- C. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Deliver units to site with electronically commutated fan motors factory mounted in units. If these components are not completely assembled, contractor shall be responsible for all expenses associated with installation, testing, and vibration balancing of fan(s).

1.9 START-UP AND OPERATING REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.10 WARRANTY

- A. The equipment manufacturer shall provide, at no additional cost, a STANDARD PARTS WARRANTY that covers a period of one year from owner acceptance of substantial project completion. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.
- B. Provide a full parts warranty for five year from project substantial completion acceptance by owner, whichever occurs first.
- C. Contractor to certify and provide warranty service within 4 hours to each site by factory trained personnel once informed by the owner of a problem.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Approved manufacturers shall be Trane,
- B. Preapproved equal – Manufacturers that secure written approval through the Virgin Island Department of Education prior to systems being proposed and or bid. Equal system must have screw compressor and meet the specification including all scheduled performance.
- C. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 GENERAL UNIT DESCRIPTION

- A. Manufacturer shall provide unit arranged for draw-through application. Unit layout and configuration shall be as defined in project plans and schedule. Blow-through is only acceptable when consideration is given to capturing downstream moisture carryover. Considerations include downstream moisture eliminators and/or extended blank modules with condensate drain pans.

2.3 UNIT CASING

- A. The entire air handler shall be constructed of galvanized steel. The removal of access panels shall not affect the structural integrity of the unit once the unit is installed. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
- B. Access panels shall be on both sides or front of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
- C. Units shall ship as one or two modules completely factory-assembled including all coils, fans, motors, drives, dampers and filters.
- D. Access Panels: Removable access panels shall be provided on both sides or front of the unit to facilitate service access to drain pans, motors, drive components and bearings. Panels shall be gasketed. Access panel for filter removal shall be provided on both sides or front of the unit.
- E. Cabinet: Casing shall be manufactured of heavy gauge galvanized steel. All removable panels shall be gasketed to minimize air leakage.
- F. INSULATION - High density, foil-faced - Interior surface of unit casing shall be acoustically and thermally lined. Insulation shall be installed with adhesive. Insulation shall have a minimum R-Value of 4, shall be UL listed, and shall meet ASTM C 665 Bacteriological Standard requirements. The installation shall comply with NFPA90A and B requirements. All exposed edges shall be sealed to prevent erosion of fibers into the airstream. If edges of fiberglass insulation are exposed, the manufacturer shall be responsible for sealing exposed edges with mastic sealer to prevent erosion into the airstream.

2.4 COILS

- A. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
- B. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil are as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- C. Construct coil casings of galvanized steel. End supports shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

D. Hydronic Coils

1. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit air-flow
2. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water.
3. Headers shall be constructed of round copper pipe.
4. If unit is provided with 1/2 inch O.D. coils, the minimum tube wall thickness shall be 0.016 inch thick copper. If unit is provided with 3/8 inch O.D. coils, the minimum tube wall thickness shall be 0.014 inch thick copper. All fins shall be copper.

2.5 DRAIN PAN

- A. Drain Pan(s) shall be constructed of corrosion resistant material. Acceptable materials include polymer or 304 stainless steel. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section.
- B. Drain pan manufacturer shall either insulate bottom of drain pan with closed cell foam or provide double wall internally insulated construction to eliminate bottom sweating.
- C. Drain pan shall be sloped in two planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation instructions. Units without drain pans sloped in two planes shall coat drain pans with anti-microbial treatment. Drain pan(s) shall have main and auxiliary drain connections with auxiliary outlet higher than the main connection.
- D. Coil(s) shall be mounted above the drain pan to facilitate easy and complete inspection, cleaning and removal. Coil(s) may not sit in drain pan.
- E. On units not provided with factory installed internal drain trap, the drain pan shall be capable of being rotated in the field between right and left hand connections.

2.6 FACTORY PIPING PACKAGE

- A. Unit manufacturer shall provide piping package factory assembled and shipped loose for field installation. Control valves shall be selected with a valve flow coefficient providing a branch authority between 25 and 70% (waterside pressure drop of the valve divided by the waterside pressure drop of the branch circuit piping including the coil). Two-way or three-way piping packages shall be available.
 1. Two way piping packages shall include the following component connected in the direction of water flow:
 - a. Supply ball valve
 - b. 2-way Belimo pressure independent control valve

- c. Return ball valve
- 2. Three-way piping packages shall include the following component connected in the direction of flow:
 - a. Supply ball valve
 - b. Balance fitting
 - c. 3-way mixing control valve
 - d. Return ball valve

2.7 FANS

- A. Provide single-wheel, forward curved centrifugal fans as specified on the schedule.

2.8 MOTORS AND DRIVES

- A. All motors shall be factory-installed and run tested. To facilitate field replacement of motors, a removable fan inlet cone shall be provided on the drive side of the fan/motor assembly.
- B. Motor shall be ECM programmable type for blower coil chilled water class room quiet operation. The motor shall be preprogrammed in the factory to meet the specified airflow requirements.
- C. Fan motor shall have permanently lubricated and sealed bearings, protected by an internal thermal overload.
- D. Motors shall be selected to operate continuously at 104 F (40 C) ambient without tripping on overloads. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.
- E. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in star-up and services personnel in maintenance:
 - 1. Fan motor part number
 - 2. Fan design RPM and motor HP

2.9 FILTERS

- A. Provide removable two-inch-thick merv 12 rated filters easily removable from either side of the unit. All units shall use standard filter sizes.
- B. A spare set of operational filters shall be supplied with each unit from the factory.

2.10 CONTROLS

- A. Fan motor and end devices shall be wired back to a control box enclosure. A junction box shall be provided for single point power connection.
- B. The control package shall include the following at a minimum:
 - 1. 24 VAC transformer
 - 2. Disconnect switch (not included with electric heat)
 - 3. Low Temperature detection device
 - 4. Fan status switch
 - 5. Condensate overflow float switch
 - 6. Two-position or three position control valves shown on documents.
- C. Control Interface - Unit shall be factory run tested and end devices shall be factory wired to terminal strip in a external junction box and tested for wiring continuity.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are ready to receive work and opening dimensions are as <<OPENING_VERIFICATION_TYPE>>

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide units with shut-off valve on supply and lockshield balancing valve on return piping if factory packages are not factory provided.

3.3 CLEANING

- A. Clean work.
- B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- C. Install new filters.

3.4 Install and wire direct digital control system and thermostat provided by BAS contractor in accordance with section 230923

3.5 BC_A SCHEDULE

Drawing Code	1	2	3
Manufacturer			
Model			
Supply Fan			
Air Flow (CFM)			
Static Pressure (in.)			
Motor (hp)			
Cooling			
Sensible (Btuh)			
Total (Btuh)			
Entering DB Temp (F)			
Entering WB Temp (F)			
Leaving DB Temp (F)			
Leaving WB Temp (F)			
Nominal Capacity (tons):			
Remarks			

END OF SECTION 238219

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

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. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Fire Rated Sleeves for cables.
4. Grout.
5. Common electrical installation requirements.
6. Utility company coordination requirements.

1.3 REFERENCES

- A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. A: Ampere, unit of electrical current.
2. AC or ac: Alternating current.
3. AF : Amp Frame
4. AFCI: Arc-fault circuit interrupter.
5. AIC: Ampere interrupting capacity.
6. AL, Al, or ALUM: Aluminum.
7. AP: Wireless access point
8. ASD: Adjustable-speed drive.
9. AT: Amp Trip
10. ATS: Automatic transfer switch.
11. AV: Audio-Video, audio-visual
12. AWG: American wire gauge; see ASTM B258.
13. BAS: Building automation system.
14. BESS: Battery Energy storage system.
15. BIL: Basic impulse insulation level.
16. BIM: Building information modeling.
17. BJ: Bonding jumper
18. BKR: Breaker
19. BMS: Building Management System
20. C: Conduit
21. CAD: Computer-aided design or drafting.
22. CATV: Community antenna television, Cable Television

23. CB: Circuit breaker.
24. CCTV: Closed circuit television
25. CFCI: Contractor furnished contractor installed
26. CKT: Circuit
27. CU or Cu: Copper.
28. CU-AL or AL-CU: Copper-aluminum.
29. dB or DB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
30. DC or dc: Direct current.
31. DDC: Direct digital control (HVAC).
32. DISC: Disconnect
33. DP: Distribution Panelboard
34. DW: Dishwasher
35. ECS: Emergency communication system
36. EGB: Electrical grounding busbar
37. EGC: Equipment grounding conductor.
38. EMD: Estimated maximum demand.
39. EMGB: Electrical main grounding busbar
40. EMI: Electromagnetic interference.
41. EP: Explosion proof
42. EPS: Emergency power supply.
43. EPSS: Emergency power supply system.
44. ER: Existing to be relocated
45. ERMS: Energy reduction maintenance switch
46. EV: Electric vehicle.
47. EWC: Electric water cooler
48. FA: Fire Alarm
49. FAA: Fire alarm annunciator
50. FACP: Fire alarm control panel
51. FC or fc: Footcandle, a unit of illuminance equal to one lumen per square foot.
52. FLA: Full load amps
53. FLC: Full-load current.
54. FS: Flow Switch
55. FSD: Fire smoke damper
56. ft.: Foot.
57. G or GND: Equipment grounding conductor
58. GEC: Grounding electrode conductor.
59. GEN: Generator
60. GFI or GFCI: Ground-fault circuit interrupter.
61. GFPE: Ground-fault protection of equipment.
62. HACR: Heating, air conditioning, and refrigeration.
63. HDPE: High-density polyethylene.
64. HH: Handhole
65. HOA: Hand-off-automatic
66. HP or hp: Horsepower.
67. HVAC: Heating, ventilating, and air conditioning.
68. Hz: Hertz.
69. IC: Intercom
70. IG: Isolated ground.
71. inch: Inch. To avoid confusion, the abbreviation "in." is not used.

- 72. IP: Ingress protection rating (enclosures); Internet protocol (communications).
- 73. IR: Infrared.
- 74. IS: Intrinsically safe.
- 75. ITE: Information technology equipment.
- 76. JB: Junction Box
- 77. KAIC or kAIC: Kiloampere interrupting capacity.
- 78. kcmil or MCM: One thousand circular mils.
- 79. KV or kV: Kilovolt.
- 80. KVA or kVA: Kilovolt-ampere.
- 81. kVAr or kVAR: Kilovolt-ampere reactive.
- 82. KW or kW: Kilowatt.
- 83. kWh: Kilowatt-hour.
- 84. LAN: Local area network.
- 85. LT: Light
- 86. LTG: Lighting
- 87. lb: Pound (weight).
- 88. LCD: Liquid-crystal display.
- 89. LED: Light-emitting diode.
- 90. LRC: Locked-rotor current.
- 91. MCA: Minimum circuit ampacity
- 92. MCB: Main circuit breaker
- 93. MCC: Motor-control center.
- 94. MH: Manhole
- 95. MLO: Main lugs only.
- 96. MOCP: Maximum overcurrent protection
- 97. MRTS: Motor rated toggle switch
- 98. MSB: Main switchboard
- 99. MTD: Mounted
- 100. MTG: Mounting
- 101. MTS: Main transfer switch
- 102. MVA: Megavolt-ampere.
- 103. N: Neutral
- 104. N.C. or NC: Normally closed.
- 105. NF: Non-fused
- 106. NiCd: Nickel cadmium.
- 107. NL: Night light.
- 108. N.O. or NO: Normally open.
- 109. OCPD: Overcurrent protective device.
- 110. OFCI: Owner furnished contractor installed.
- 111. ONT: Optical network terminal.
- 112. P: Pole – referring to an electrical position in a panel
- 113. PA: Public address
- 114. PB: Pull box
- 115. PC: Personal computer.
- 116. PF or pf: Power factor.
- 117. PH or ph: Phase
- 118. PHEV: Plug-in hybrid electric vehicle.
- 119. PIV: Post indicator valve.
- 120. PLFA: Power-limited fire alarm.
- 121. PoE: Power over Ethernet.

- 122. PV: Photovoltaic.
- 123. PVC: Polyvinyl chloride.
- 124. PWR: Power.
- 125. RCP: Reflected ceiling plan.
- 126. RECPT: Receptacle.
- 127. REF: Reference.
- 128. RFI: Radio-frequency interference (electrical); Request for interpretation (contract).
- 129. RMS or rms: Root-mean-square.
- 130. RPM or rpm: Revolutions per minute.
- 131. SCCR: Short circuit current rating.
- 132. SD: Smoke damper.
- 133. SEC: Secondary.
- 134. SPD: Surge protective device.
- 135. sq.: Square.
- 136. SWD: Switching duty.
- 137. SWBD: Switchboard.
- 138. TBB: Telecommunications bonding backbone.
- 139. TC: Time clock.
- 140. TCP/IP: Transmission control protocol/Internet protocol.
- 141. TGB: Telecommunications grounding busbar.
- 142. TMGB: Telecommunications main grounding busbar.
- 143. TO: Telecommunications outlet.
- 144. TR: Telecommunications room.
- 145. TR: Tamper resistant.
- 146. TS: Tamper switch.
- 147. TV: Television.
- 148. TVSS: Transient voltage surge suppressor.
- 149. UG : Underground.
- 150. UL: Underwriters Laboratories, Inc. (standards) or UL LLC (services).
- 151. UPS: Uninterruptible power supply.
- 152. USB: Universal serial bus.
- 153. UV: Ultraviolet.
- 154. V: Volt, unit of electromotive force.
- 155. Vac or V(ac): Volt, alternating current.
- 156. Vdc or V(dc): Volt, direct current.
- 157. VA: Volt-ampere, unit of complex electrical power.
- 158. VAR or VAr: Volt-ampere reactive, unit of reactive electrical power.
- 159. VFC: Variable-frequency controller.
- 160. VFD: Variable-frequency drive.
- 161. VRLA: Valve-regulated lead acid.
- 162. W: Watt, unit of real electrical power or Wire.
- 163. WG: Wire guard.
- 164. Wh: Watt-hour, unit of electrical energy usage.
- 165. WP: Weather proof.
- 166. WR: Weather resistant.
- 167. XFMR: Transformer.

1.4 DEFINITIONS

- A. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- B. "Install": Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.
- C. "Provide": Furnish and install, complete and ready for the intended use.

1.5 ACTION SUBMITTALS

- A. Product Data: For Fire Rated Sleeves for cables.

1.6 COORDINATION

- A. Trade Coordination: Include physical characteristics, electrical characteristics, device layout plans, wiring diagrams, and connections as required per Division 26, Electrical Coordination Documents. For equipment with electrical connections, furnish copy of approved submittal for inclusion in Division 26, Electrical submittal.
- B. Location of electrical outlets and equipment:
 - 1. Location of electrical outlets and equipment shown on electrical drawings are diagrammatic. Unless indicated otherwise do not use electrical drawings to locate electrical outlets and equipment.
 - 2. Luminaires and outlets:
 - a. Ceiling mounted luminaires and outlets: use architectural reflected ceiling plans and details to determine location unless indicated otherwise.
 - b. Wall mounted luminaires and outlets:
 - 1) Use architectural elevation and section drawings to determine location unless indicated otherwise.
 - 2) Where architectural elevation and section drawings do not indicate location of wall outlets then locate the outlet within 12 inches of location shown on electrical drawings considering field conditions.
 - 3) Coordinate location with consideration of owner provided equipment such as wall mounted televisions, white boards, furniture, cabinets and the like.
 - c. Floor mounted outlets: use architectural drawings to determine location unless indicated otherwise. If not clearly indicated, then send request for information to Architect.
 - d. Cabinet mounted luminaires and outlets: use cabinet details and shop drawings to determine location unless indicated otherwise.
 - e. Exterior luminaire poles and bollards: use locations indicated on civil plans and landscape plans unless indicated otherwise
 - f. Landscape luminaires: use locations indicated on landscape drawings unless indicated otherwise.
 - g. Kitchen Equipment outlets: use location and mounting height indicated on kitchen drawings unless indicated otherwise.

3. Electrical equipment: Utilize approved manufacturer's shop drawing dimensions to determine location of equipment in space. Comply with NEC 110.26 access, working space and dedicated equipment space requirements. Maintain manufacturer requirements for maintenance access.
 4. Electrical handholes and manholes: use location shown on civil plans unless indicated otherwise.
 5. Outdoor Electrical equipment: use location shown on civil plans unless indicated otherwise.
- C. Shop Drawings: Provide coordinated shop drawings which include physical characteristics of all systems, device layout plans, and control wiring diagrams. Reference individual Division 26, Electrical specification sections for additional requirements for shop drawings outside of these requirements.
- D. Electrical connections to equipment supplied by owner or other trades:
1. Prior to procurement of electrical equipment and field work coordinate with shop drawings and/or manufacturer's installation instructions the actual electrical characteristics of the equipment to be connected.
 2. Notify engineer of significant deviations or conflicts between the shop drawings and/or the manufacturer's installation instructions and information in the contract documents.
- E. Coordinate arrangement, mounting, and support of electrical 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 so connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- F. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- G. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- H. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- I. Coordinate and install wiring for appliances and systems furnished under other specification Divisions or furnished by the Owner. Install electrical wiring in accordance with manufacturer's instructions.:
1. Motorized door operators.
 2. Gymnasium scoreboard and controller.
 3. Gymnasium equipment.
 4. Kitchen equipment including walk-in freezer and coolers.
 5. Electric water coolers.
 6. Exterior signage.
 7. Owner provided equipment

1.7 SERVING UTILITY COMPANIES.

- A. Construction drawings indicate approximate locations and routing. Coordinate exact placement of transformers, vaults, raceway, pads, poles, enclosures, and other equipment with the serving utility companies and civil plans. Comply with serving utility requirements for clearances, access, materials, workmanship, separation from other utilities, and other documented requirements.
- B. Coordinate with the serving utility companies, including but not limited to the Power Company, Telephone Company, and Internet Company. Verify the extent of work to be performed by the utility companies. Provide labor and materials not provided by the serving utility companies that is required for a complete and operational system.
- C. Serving Electric Utility is as follows:
 - 1. Virgin Islands Water and Power Authority (WAPA).
 - a. Address: P.O. Box 5997, Christiansted, St. Croix, U.S. Virgin Islands 00823.
 - b. Design and Construction Manager:
 - 1) Contact: Cordell Jacobs.
 - 2) Telephone: (340) 642-0946.
 - 3) E-mail: cordell.jacobs@viwapa.vi
 - c. Design and Construction Engineer:
 - 1) Contact: Belgrave D. Stedman.
 - 2) Telephone: (340) 626-4561.
 - 3) E-mail: belgrave.stedman@viwapa.vi
- D. Coordinate detailed requirements and construction schedule with serving utility companies prior to procurement of materials and work on the site.
- E. Provide detailed shop drawing illustrating routing of conduits, layout of equipment, location of adjacent utilities, structures, landscape elements, and architectural features. Obtain approval of the shop drawings from serving utility company prior to work on the site and procurement of material.

1.8 PERMITS AND FEES

- A. Owner will pay all charges and/or fees levied by the serving utility companies relative to this project.
- B. Obtain and pay all fees for permits, licensing, and inspections applicable to work of Division 26, 27, and 28.

1.9 QUALITY ASSURANCE

- A. Regulatory Requirements: Install work and materials to conform with local, State and Federal codes, and other applicable laws and regulations.
- B. Drawings are intended to be diagrammatic and reflect the Basis of Design manufacturer's equipment. Drawings are not intended to show every item in its exact location, or details of

equipment or proposed systems layout. Verify actual dimensions of systems (i.e. distribution equipment, duct banks, light fixtures, etc.) and equipment proposed to assure that systems and equipment will fit in available space. Contractor is responsible for design and construction costs incurred for equipment other than Basis of Design, including, but not limited to, architectural, structural, electrical, HVAC, fire sprinkler, and plumbing systems.

- C. Manufacturer's Instructions: Follow manufacturer's written instructions. If in conflict with Contract Documents, obtain clarification. Notify Engineer/Architect, in writing, before starting work.
- D. Items shown on Drawings are not necessarily included in Specifications or vice versa. Confirm requirements in all Contract Documents. 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.
- E. Provide Qualified Personnel that are thoroughly knowledgeable of applicable codes related to electrical systems to perform the electrical work. Installations shall be performed by skilled electrical tradesmen fully aware of the latest techniques, practices, and standards of the industry. Refer to N.E.C. Article 100-Definitions, Qualified Person.
- F. Install electrical equipment and components in a neat and workmanlike manner in accordance with recognized practices and industry standards. Refer to N.E.C. 110.12. Haphazard or poor installation practice will be cause for rejection of the work.

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 if accompanied by value analysis data indicating that substitution will comply with 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. Insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.
- B. Substitution and Variation from Basis of Design:
 - 1. The Basis of Design designated product establishes the qualities and characteristics for the evaluation of any comparable products by other listed acceptable manufacturers if included in this Specification or included in an approved Substitution Request as judged by the Design Professional.
 - 2. Proposed substitutions: If substitutions are proposed, it is the responsibility of parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to

verify and compare the characteristics and requirements of that furnished to that specified and/or shown. If greater capacity and/or more materials and/or more labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then provide compensation for additional charges required for the proper rough-in, circuitry and connections for the equipment being furnished. No additional charges above the Base Bid, including resulting charges for work performed under other Divisions, will be allowed for such revisions. Coordinate with the requirements of "Submittals". For any product marked "or approved equivalent", a substitution request must be submitted to Engineer for approval prior to purchase, delivery, or installation.

2.2 SLEEVES FOR RACEWAYS AND CABLES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- C. EMT: Electrical Metallic Tubing.
- D. PVC: Schedule 40 or 80.

2.3 FIRE RATED SLEEVES FOR CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M
 - 2. Hilti
 - 3. Specified Technologies, Inc (STI)
 - 4. Wiremold.
- B. Factory assembled rectangular steel pathway containing an intumescent insert material that adjusts automatically to cable addition or subtraction.
- C. Sleeve shall have an F Rating equal to or greater than the rating of the wall in which the sleeve is installed.
- D. Sleeve shall be UL listed and bear the UL Classification marking.
- E. Sleeve shall be tested in accordance with ASTM E814 (ANSI/UL1479).

- F. Provide square wall plate kits for single sleeve applications. Provide multi-gang wall/floor plate kits for ganged applications.
- G. Subject to compatibility with requirements and field conditions, i.e. sleeve size, wall thickness, etc., acceptable products include the following:
 - 1. 3M Fire Barrier Pass-Through Devices
 - 2. Hilti Speed Sleeves
 - 3. Specified Technologies Inc. EZ-Path Fire Rated Pathway (series 33).
 - 4. Wiremold Flamestopper FS4 Series

2.4 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 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 Work specified in Division 26. Consult Architect for resolution of conflicting requirements.
- B. Comply with NECA 1.
- C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- D. 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.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- F. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete, masonry and gypsum board walls, or fire-rated floor and wall assemblies.

- B. Sleeves are required where cables (not in raceway) penetrate walls or floors. Sleeves are not required where raceways penetrate walls, except where raceways penetrate exterior walls/foundations below grade.
- C. Concrete Slabs and Walls: Install sleeves during erection of slabs and walls.
- D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Provide insulated bushings on EMT sleeves for cable not in conduit. Bushings shall be plenum rated where installed in a plenum.
- G. Extend sleeves installed in floors 4 inches (100 mm) above finished floor level unless noted otherwise.
- H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe or PVC, schedule 40 or 80, sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve. Cut sleeves to length for mounting flush with both surfaces of walls.
- M. Fire Rated Sleeves for cables: Fabricate openings in wall or floor assemblies per manufacturer's recommendations.

3.3 SLEEVE APPLICATION

- A. Sleeves for cables not in conduit:
 - 1. Through Non-Rated Interior Walls: EMT sleeves.
 - 2. Through Non-Rated Floors: EMT sleeves.
 - 3. Through Fire Rated Interior Walls: Fire Rated Sleeves for cables.
 - 4. Through Fire Rated Floors: Fire Rated Sleeves for cables.

B. Sleeves for conduits:

1. Through Exterior Walls Below Grade: Refer to details on structural Drawings. Absent any such details provide cast iron pipe or PVC, Schedule 40 or 80, sleeve two trade sizes larger than the conduit.

C. Sleeves for Cable Trays:

1. Through Non-Rated Interior Walls: Rectangular galvanized sheet metal opening.
2. Through Fire Rated Walls: Stop cable tray 6 inches maximum for each side of wall and provide multiple fire rated sleeves for cables with combined allowable area for cable equal to the capacity of the cable tray unless noted otherwise.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 260500

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Medium-voltage tapes.
6. Arc-proofing materials.
7. Fault indicators.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Indicate location of each cable, splice, and termination.
- B. Material Certificates: For each type of cable and accessory.
- C. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.
- D. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aetna Insulated Wire, Inc.
 2. General Cable; Prysmian Group North America.
 3. Okonite Company (The).
 4. Rome Cable Corporation.
 5. Southwire Company.
- B. Cable Type: 25kV CU 133% EPR Full Neutral LLDPE Primary UD
- C. Conductor Insulation: Ethylene-propylene rubber.
1. Voltage Rating: 25 kV.
 2. Insulation Thickness: 133 percent insulation level.
 3. Continuous Operation Temperature Rating: 105°C for normal operation
- D. Conductor: Copper.
- E. Concentric Neutral: Helically applied soft drawn bare copper full concentric neutral.
- F. Comply with UL 1072, AEIC CS8, and ICEA S-94-649.
- G. Conductor Stranding: Concentric lay, Class B.
- H. Strand Filling: Conductor interstices are filled with impermeable compound.
- I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
- J. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
 2. Eaton.
 3. MP Husky USA Cable Tray & Cable Bus.
 4. nVent (RAYCHEM).
- B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- C. Copper-Conductor Connectors: Copper shear bolt connectors.

2.4 SOLID TERMINATIONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
 2. Eaton.
 3. Engineered Products Company.
 4. nVent (RAYCHEM).
- B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations:
 - a. Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
 - b. Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
 - c. Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
 - d. Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
 2. Eaton.
 3. MP Husky USA Cable Tray & Cable Bus.
 4. nVent (RAYCHEM).
- C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- D. Load-Break Cable Terminators: Elbow-type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- E. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

- F. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M.
 - 2. Eaton.
 - 3. MP Husky USA Cable Tray & Cable Bus.
 - 4. nVent (RAYCHEM).
- C. Ethylene/propylene rubber-based, 30 mil (0.76 mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

2.7 ARC-PROOFING MATERIALS

- A. Description: Fire retardant, providing arc flash protection.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M.
 - 2. Eaton.
 - 3. MP Husky USA Cable Tray & Cable Bus.
 - 4. nVent (RAYCHEM).
- C. Tape for First Course on Metal Objects: 10 mil (250 micrometer) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.
- E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

2.8 FAULT INDICATORS

- A. Indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
- B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.9 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-94-649 before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inch (1200 to 1800 mm) on the pull rope.
 - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 - 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
 - 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install "buried-cable" warning tape 12 inch (305 mm) above cables.
- E. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.
- F. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- G. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

- H. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."
- I. Install fault indicators on each phase where indicated.
- J. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- K. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
 - 4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
 - 5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
- B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Copper building wire rated 600 V or less.
 - 2. Aluminum building wire rated 600 V or less.
 - 3. Metal-clad cable, Type MC, rated 600 V or less
 - 4. Photovoltaic cable, Type PV, rated 2000 V
 - 5. Cord Products
 - 6. Connectors, splices, and terminations rated 600 V and less.

- B. Related Requirements:

- 1. Section 260533 "Raceway and Boxes for Electrical Systems" for allowable applications of raceways and cable assemblies. Cable assemblies, such as Type MC cable, shall not be permitted unless noted otherwise.
 - 2. Section 260553 "Identification for Electrical Systems" for conductor color coding.

1.3 DEFINITIONS

- A. PV: Photovoltaic.
- B. RoHS: Restriction of Hazardous Substances.
- C. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

- A. Copper Building Wire
 - 1. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
 - 2. Conductors: complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- B. Aluminum Building Wire
 - 1. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
 - 2. Conductors: 8000 series electrical grade aluminum alloy, complying with ASTM B800 and ASTM B801.
 - 3. Permitted for feeders greater than 100 amps only.
 - 4. Aluminum building wire shall not be used for connections to any equipment that has not been used UL tested with aluminum building wire connections or where such connection will void or reduce the manufacturer's warranty. Such equipment may include HVAC equipment and elevators.
 - 5. Not permitted for motor feeders or branch circuits.
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductor Insulation:
 - 1. Type THHN and Type THWN-2: Comply with UL 83.
 - 2. Type XHHW-2: Comply with UL 44.
- E. Temperature Ratings: All conductors shall be rated 75-degree C minimum.

2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Comply with UL 1569.
 - 3. RoHS compliant.
- C. Single circuit.
- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- E. Ground Conductor: Insulated.
- F. Conductor Insulation:
 - 1. Type THHN/THWN-2: Comply with UL 83.
 - 2. Type XHHW-2: Comply with UL 44.
- G. Armor: Steel or Aluminum, interlocked.
- H. Jacket: PVC applied over armor.

2.3 PHOTOVOLTAIC CABLE, TYPE PV

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CME Cable
 - 2. Encore
 - 3. General Cable
 - 4. Southwire
- B. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 2000 V.
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- E. Conductor Insulation: Comply with UL 44 and UL 4703.

2.4 CORD PRODUCTS

- A. Description: Flexible, hard-use service cord with black rubber jacket. Type SO, SOW, etc.
- B. Circuits: Single circuit and multi-circuit with color coded conductors. Separate neutral conductors shall be included for each circuit originating from a unique overcurrent protection device.
- C. Conductors: Copper, complying with ASTM B8 for stranded conductors.
- D. Ground Conductor: Insulated.
- E. Conductor Insulation:
 - 1. Type THHN/THWN-2: Comply with UL 83.

2.5 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Lugs for attachment to telecommunications systems grounding busbars shall be two-hole with long barrels and irreversible crimp terminations.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. 100 amps and less: Copper stranded.
 - 2. Over 100 amps: Copper or aluminum, stranded.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. PV Circuits:

1. 100 amps and less: Copper, stranded.
2. Over 100 amps: Copper or aluminum, stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Feeders to Distribution Equipment and Panelboards: Type XHHW-2, single conductors in raceway.
- C. Exterior Feeders and branch circuits routed horizontally on roofs: Type XHHW-2, single conductors in raceway.
- D. Other Feeders and Branch Circuits: Type THHN-THWN, single conductors in raceway.
- E. Feeders connected from the load-side of VFDs to electric motors: Type XHHW-2 single conductors installed in a raceway or Type XHHW-2 MC cable where permitted.
- F. Feeder to Fire Pump: Type XHHW-2 single conductors in raceway routed underground under 2 inches minimum of concreted or encased in 2 inches of concrete.
- G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- H. PV Circuits: Type PV in raceway or free air.
- I. Metal Clad Cable
 1. Uses permitted:
 - a. Branch circuits rated less than 50 amps
 - b. In areas that have accessible plenum space
 - c. Feeders connected to load side of VFD to motor
 2. Uses not permitted:
 - a. Feeders
 - b. Homeruns
 - c. Between rooms
 - d. Inside block walls
 - e. Areas where there is no access to the ceiling space
 - f. Areas that have no ceiling or exposed structure
 - g. Exposed
 - h. Wet or damp areas

3.3 CONDUCTOR SIZES

- A. Minimum Wire Size (Interior Work): No. 12 AWG, except No. 14 AWG shall be permitted for signal, pilot control circuits and fixture whips.
- B. Minimum Wire Size (Exterior Work): No 10 AWG.
- C. PV Circuit Minimum Wire Size: No. 10 AWG

- D. Use #10 AWG minimum conductor size in lieu of #12 AWG minimum for 20 ampere, 120 volt branch circuits where homeruns are longer than 75 feet and for 20 ampere, 277 volt branch circuits where homeruns are longer than 175 feet. Increase in size as required for a maximum of 3 percent voltage drop from panel to load.
- E. Derate conductors based on quantity of current carrying conductors in each conduit. Refer to the NEC for derating factors.
- F. Derate conductors for high ambient temperatures. Refer to the NEC for derating factors.

3.4 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Branch circuits serving receptacles and lighting loads shall have dedicated neutral conductors and shall not share a common neutral conductor. The use of handle ties across single pole circuit breakers to allow the use of a common neutral is not acceptable.
- H. Multiwire Branch Circuits and Shared Neutrals:
 - 1. Multiwire branch circuits (as defined by the NEC) and shared neutrals (common grounded conductors) are not permitted, except as follows:
 - a. Wherever a multiwire branch circuit is specifically indicated on the Drawings and a multi-pole breaker is provided in the panel from which it originates as a means to simultaneously disconnect all ungrounded conductors.
 - b. Wherever three (3) individual 120-volt 20-amp branch receptacle circuits originate from three (3) adjacent 20-amp 1-pole circuit breakers with identified interlocked handle ties to simultaneously disconnect all three phase conductors (A-B-C).
 - 2. Derating factors shall be applied, per NEC Article 310, to multiple current-carrying conductors installed within the same conduit. Neutral conductors shall be regarded as current-carrying conductors. Wire sizes shall be increased as needed to maintain the ampacity that corresponds to the overcurrent protection device rating.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.]
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepared test reports.
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. 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.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 1. Procedures used.
 2. Results that comply with requirements.
 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Photographic evidence of underground electrode(s) installation.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Ground rods.
 - 3) Ground rings.
 - 4) Grounding arrangements and connections for separately derived systems.
 - 5) Include recommended testing intervals.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

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

2.2 ELECTRICAL GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chatsworth.
 - 2. Cooper B-Line.
 - 3. Erico.
 - 4. Harger.
- B. Products shall be UL listed.
- C. Copper busbar, 0.25-inch thick minimum, insulated stand-offs, factory predrilled standard size holes.
- D. Electrical Grounding Busbars: Height shall be 4-inches minimum and length shall be 24-inches minimum unless indicated otherwise on Drawings.
- E. Connector Lugs: Lugs for connecting to grounding electrode conductors and bonding conductors shall be UL listed two-hole, long barrel, electro tinplated compression lugs.

2.3 TELECOMMUNICATIONS GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line
 - 2. Chatsworth
 - 3. Erico.
 - 4. Harger
 - 5. Legrand Ortronics
 - 6. Panduit
- B. Products shall be UL listed meet the specification of TIA/EIA 607 and conform to BICSI recommendations.
- C. Copper busbar, 0.25-inch thick minimum, insulated stand-offs, factory predrilled standard size holes per TIA/EIA 607 standard.
- D. Telecommunications Main Grounding Busbars: Height shall be 4-inches. Length shall be 20-inches minimum unless indicated otherwise on Drawings. Chatsworth 40153 series or equal.
- E. Telecommunications Grounding Busbars: Height shall be 2-inches. Length shall be 10-inches minimum unless indicated otherwise on Drawings. Chatsworth 13622 series or equal.

- F. Connector Lugs: Lugs for connecting to telecommunications grounding busbars shall be UL listed two-hole, long barrel, electro tinplated compression lugs.

2.4 CONDUCTORS

- A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Length of grounding bus as required for connections. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.5 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with zinc-plated bolts.

- a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.6 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0AWG minimum.
 1. Bury at least 30 inches (750 mm) below grade.
- C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
- E. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

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

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.

- B. Provide grounding as required by the serving utility company. Grounding shall be provided at, but not limited to, the following locations:
 - 1. Transformer
 - 2. Meter
- C. Grounding Handholes: Install a driven ground rod through handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend 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 handhole through a waterproof sleeve in handhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 TELECOMMUNICATIONS GROUNDING

- A. Provide grounding in accordance with TIA 607 and as indicated on the Drawings.

3.6 INSTALLATION

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

- C. Ground Rods: Drive rods until tops are 2 inches (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 all below-grade connections.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of each building.
 - 1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- H. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than [20 feet (6 m)] long, coil excess conductor within base of foundation.
 2. 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.
- I. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

- A. Prior to covering underground UFER grounds and connections to ground rods, take digital photographs of the grounding electrodes including conductor connections. Record locations of each photograph. Submit to A/E for documentation purposes.
- B. Perform tests and inspections.
- 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 a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at service disconnect enclosure grounding terminal.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- D. Grounding system will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Requirements:

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

1.3 ACTION SUBMITTALS

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

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.
 - f. Fasteners.
 - g. Anchors.
 - h. Saddles.
 - i. Brackets.
- 2. Include rated capacities and furnished specialties and accessories.

- B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

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

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

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

1.4 INFORMATIONAL SUBMITTALS

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

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Projectors.

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
 2. Component Importance Factor:
 - a. Arthur Richards: 1.5.
 - b. Charlotte Amalie: 1.5.
 - c. Boschulte: 1.25.
 3. Component Amplification Factors and Component Response Modification Factors: Per to ASCE/SEI 7

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 2. Material for Channel, Fittings, and Accessories:
 - a. Interior Conditioned spaces: Galvanized steel
 - b. Exterior and non-conditioned spaces: Stainless steel, Type 316.
 3. Channel Width: Selected for applicable load criteria.
 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel (conditioned spaces) and Stainless-steel (non-conditioned and exterior spaces) hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel (conditioned) or stainless steel (non-conditioned), for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

2. 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.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
5. Toggle Bolts: All-steel(conditioned) or Stainless-steel (non-conditioned) springhead type.
6. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA 1.
 2. NECA 101
 3. NECA 105.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 - 6. To Light Steel: Sheet metal screws.
 - 7. 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.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches (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 4500-psi (31.0-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Comply with requirements in Section 099113 "Exterior Painting" 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.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Requirements:

- 1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
- 2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
- 3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
- 4. Section 260519 "Low-Voltage Power Conductors and Cables" for cable assemblies such as metal clad cable. See part 3 in section 260513 for application for metal clad cable.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. IMC: Intermediate metal conduit.
- C. LFMC: Liquidtight flexible metal conduit.
- D. LFNC: Liquidtight flexible nonmetallic conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Metal Conduit:
 - 1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. GRC: Comply with ANSI C80.1 and UL 6.
 - 3. IMC: Comply with ANSI C80.6 and UL 1242.
 - 4. PVC-Coated Steel Conduit: PVC-coated IMC.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
 - 5. EMT: Comply with ANSI C80.3 and UL 797.
 - 6. FMC: Comply with UL 1; zinc-coated steel.
 - 7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- B. Metal Fittings:
 - 1. Comply with NEMA FB 1 and UL 514B.
 - 2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Fittings, General: Listed and labeled for type of conduit, location, and use.
 - 4. Fittings for EMT:

- a. Material: Steel.
 - b. Type: Setscrew or compression.
- 5. 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.
- 6. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- C. Joint Compound for IMC, or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Nonmetallic Conduit:
 - 1. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
 - 3. Rigid HDPE: Comply with UL 651A.
 - 4. Continuous HDPE: Comply with UL 651B.
- B. Nonmetallic Fittings:
 - 1. Fittings, General: Listed and labeled for type of conduit, location, and use.
 - 2. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
 - 3. Below Grade Long Radius Elbows:
 - a. Conduits 2 inches to 2.5 inches: use minimum 24-inch radius, Fiberglass Elbow.
 - b. Conduits larger than 2.5 inches: use minimum 36-inch radius Fiberglass Elbow.
 - 4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Single Channel for Power locations: One-piece raceway with matching device boxes, fittings and all components necessary for a complete raceway system.
 - a. Design Basis: Wiremold 500 or 700 series or equivalent to meet fill requirements.
 - b. Finish: Manufacturer's standard enamel.
 - b. Color: Gray.

2. Two-Compartment Divided Surface Metal Raceway for Power and Data: UL Listed two-piece steel construction with baked-on powder-coat epoxy finish. Provide divider integral with base. Corner- and T-fittings shall have a 2.5-inch (minimum) bend-radius to support CAT-6A communications cables.
 - a. Design Basis: Wiremold 4000 series with V4050 mounting brackets and V5507D faceplates for duplex receptacles. Provide wiring device brackets for low-profile mounting of standard duplex receptacles in-line with the raceway.
 - b. Provide angled communication endplates/raceway adapters ARA-S2 that angle the IT connector/jack to increase cabling bend-radius capacity.
 - c. Provide manufacturer's special fittings and radius control inserts to meet bend radius compliance standards for augmented Cat-6 (6A) communications cabling.
 - d. Technology outlets shall provide two (2) labeling covers compliant with TIA-606 standard.
 - e. Device Spacing:
 - 1) Power Outlets (120V Duplex Receptacles): 36 inches on-center, unless otherwise indicated on the drawings.
 - 2) Technology (IT) Outlets: 36 inches on-center, unless otherwise indicated on the drawings.
 - f. Include vertical raceway at each end of horizontal raceway up to above the accessible ceiling (or above bottom cord of ceiling joists if exposed structure). Include 90-degree bends with maximum bend-radius available.
 - g. Include all components necessary for fully equipped, complete, and functional raceway system.
 - h. Color: Gray.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: 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.
- A. Steel Surface-Mount Boxes for Finished Spaces (only where specified): NEMA OS 1, cast bell-box style, no visible knockouts, no holes, no gaps, no sharp edges, smooth, size to match flush faceplate dimensions.
- B. Metal Floor Boxes:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell
 - b. ABB
 - c. Legrand/Wiremold
 - d. Steel City

- e. FSR
- 2. Material: sheet metal.
- 3. Type: Fully adjustable.
- 4. Shape: Rectangular.
- 5. 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.
- 6. Multi-Compartment Floor Boxes up to 6 gangs:
 - a. Provide multi-service shallow stamped steel recessed floor box, fully adjustable with feed-through tunneling to adjacent compartments.
 - b. Duplex receptacles: provide as indicated on the drawings
 - c. Telecom jacks: provide as indicated on the drawings
 - d. Audio Visual connectors: provide as indicated on the drawings
 - e. Provide water resistant activation cover meeting UL scrub water exclusion requirement.
 - f. Basis of design Legrand/Wiremold RFB-SS series.
 - g. Include all accessories for a complete installation.
 - h. Floor Box Cover Assembly:
 - 1) Terrazzo or finished concrete floors: Flangeless lid flush with finished floor, flat smooth surface (no inserts), die-cast aluminum with brushed aluminum finish. Legrand/Wiremold FloorPort FP Series. Lid must be installed exactly flush with the finished floor—no exceptions.
 - 2) Carpet, tile, wood, or other floor types: Flanged lid, flat smooth surface with no inserts, die-cast aluminum with brushed aluminum finish, Legrand/Wiremold FloorPort FP Series. Flanged lid must be installed tight to floor—no exceptions.
- 7. Single Compartment Floor boxes:
 - a. Floor Boxes shown on the drawings with a single duplex receptacle, without any telecom outlets or audiovisual outlets:
 - 1) Cast iron, fully adjustable single-gang recessed floor box, single service, 3/4" conduit tapping, adjustable to floor elevation.
 - 2) Basis of Design: Hubbell SystemOne S1CFB series. Provide universal flange and cover assembly equivalent to Hubbell SystemOne S1CFCAL (carpet) or S1TFCAL (floor tile). Provide Hubbell SystemOne sub-plate S1R4SPDUPLEX.
 - 3) Brushed aluminum faceplate, style to accommodate wiring device indicated
 - 4) Provide accessories for a complete and professional installation.
 - b. Floor boxes in food service locations with single outlet:
 - 1) Cast iron, fully adjustable single-gang recessed floor box, single service, 3/4" conduit tapping, adjustable to floor elevation. Basis of Design Steel City 78SC series.
 - 2) Provide above floor service fitting, brushed aluminum, 1" conduit nipple for direct screw-threading into floor box. Basis of Design Steel City SFH-50 series.
 - 3) Brushed aluminum faceplate, style to accommodate wiring device indicated.
 - 4) Provide accessories for a complete and professional installation.
- C. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

- D. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb (32 kg).
 - 1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
 - F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773 galvanized, cast iron with gasketed cover.
 - G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - H. Device Box Dimensions: 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep).
 - I. Gangable boxes are allowed.
 - J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 for indoor dry locations and Type 4 for wet and outdoor locations with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- 2.5 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING
- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Size: minimum as required by NFPA 70 unless larger size is indicated on drawings OR as indicated on plans
 - 4. Sidewalk applications with a safety factor for occasional non-deliberate traffic comply with SCTE 77 Tier 5 (5000 pounds design load).
 - 5. Driveway, parking lot and off-road applications subject to occasional non-deliberate heavy vehicular traffic comply with SCTE 77 Tier 15 (15000 pounds design load).
 - B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following: Oldcastle, Armormat, Quazite (Hubbell), Newbasis, or approved.
 - 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, Match system (ie electric, data, telecom, fire alarm, etc.).

7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 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. 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.
 2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Above Grade Exposed Conduit: GRC or IMC.
 2. Concealed Conduit, Aboveground: GRC or IMC.
 3. Underground Conduit:
 - a. Under footprint of building: RNC, Type EPC-40-PVC, direct buried or as indicated on the drawings.
 - b. Outside of the building footprint: RNC, Type EPC-40-PVC or HDPE schedule 40
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage and in conditioned space: EMT.
 2. Exposed, Not Subject to Severe Physical Damage and in conditioned space: EMT.
 3. Exposed and Subject to Severe Physical Damage or in unconditioned space: GRC or IMC. Raceway 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: IMC.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size:
1. Indoor areas: 1/2-inch trade size minimum
 2. Buried, below or in concrete slab: 3/4-inch trade size minimum
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. 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 or compression, steel fittings. Comply with NEMA FB 2.10.
 4. Use fittings as follows:
 - a. Outdoor and wet/damp areas: compression
 - b. Conduits larger than 1-inch trade size: compression
 - c. Conduits 1-inch and smaller trade size: set screw or compression
 5. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install surface raceways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Do not install raceways or electrical items on any rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Complete raceway installation before starting conductor installation.
- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines. The following are exceptions for concealing conduits:
 - 1. Where specifically noted or indicated on the drawings
 - 2. Electrical rooms with surface mounted panels
 - 3. Mechanical rooms
 - 4. In open ceilings with exposed structure
 - 5. Unfinished utility corridors with exposed ceiling structure.
 - 6. In finished spaces only where specifically identified on the drawings provide surface metal raceway and surface-mount style boxes are painted to match the surrounding finishes. Coordinate work directly with contractor responsible ceiling, walls, and partition finishes.
- K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- L. Raceways Embedded in Slabs:
 - 1. Conduit embedded in concrete slabs shall be positioned within the middle third of the slab and secured with approved supports. In no case shall the outside dimension of the conduit exceed $\frac{1}{3}$ the thickness of the slab. Conduits in slabs shall not be placed any closer than 3 conduit diameters on-center, and they shall not cross over each other.
 - 2. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete.
 - 3. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
 - 4. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 5. Arrange raceways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
 - 6. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- M. Stub-Ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

- O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- S. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- T. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- V. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces. or from conditioned spaces to non-conditioned spaces or to exterior structures.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Conduit extending from interior to exterior of building.
 - 4. Conduit extending into pressurized duct 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.
- X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- Y. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT 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.
 - d. Attics: 135 deg F (75 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 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.
- Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations.
- AA. 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.
- BB. 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.
- CC. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- DD. Locate boxes so that cover or plate will not span different building finishes.
- EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

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

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

3.3 INSTALLATION OF CONDUIT BENEATH EXPOSED ROOF DECKING

- A. Where raceways are routed beneath roof decking that is visible from below in finished spaces, install either GRC or IMC conduit tucked-in tight within the flute of the corrugated steel decking. Run conduit in a fashion that renders it as inconspicuous as possible.
- B. Coordinate the placement of exposed conduits and junction boxes directly with the owner's jobsite representative prior to installation.
- C. No raceways shall be routed on the topside of roof decking.
- D. No EMT shall be routed within two inches below the underside of any roof decking.

3.4 INSTALLATION OF CONDUIT IN EXTERIOR MASONRY WALLS

- A. Run conduit vertically in non-grout-filled masonry cells where possible. This should be the first choice in locating conduits in exterior walls. Total conduit bends from a technology outlet (including stub-out above ceiling) shall be limited to 180-degrees or less.
- B. In rooms where masonry between windows is filled/grouted solid, conduit may be run vertically in first grouted cell adjacent to window opening (first cell should not have rebar in it). Any conduit that needs to run vertically above the masonry opening will be passing through masonry lintel above. At locations where a steel beam frames the masonry opening, a different conduit location should be selected as this will block any vertical routing of conduit in the first cell location.
- C. Avoid any conduit runs in masonry cells with rebar. If this is not possible in some locations due to the number of windows and non-grouted wall space provided, the architect/engineer will need to review this on a case-by-case basis. Data and power outlets may be shifted slightly, provided they are shifted together and not more than 24-inches, unless specifically coordinated with and approved by the architect/engineer.

3.5 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 - 2. Install backfill as specified in Section 312000 "Earth Moving."
 - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to

provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."

4. Install manufactured rigid steel conduit or fiberglass elbows for stub-ups at poles and equipment, horizontal directional changes and at building entrances through floor.
 - a. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel or fiberglass conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment if steel conduit is used.
5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."
- B. Conduits below on grade structural slabs: provide support from structural slab for conduits to hold the conduits in place due to soil settlement under the slab. Refer to geotechnical report for anticipated soil settlement amount. Support shall be anchored or embedded in the structural slab and be of corrosion resistant material. Provide support spacing in compliance to NEC for PVC conduit.

3.6 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth. Provide 12 inches depth of crushed stone or gravel under the handhole.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving concrete paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
 2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).
- H. Grass area: Provide 8-inch thick by 12-inch wide concrete around handhole.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

3.8 FIRESTOPPING

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

3.9 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

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Duct accessories.
4. Precast concrete handholes.
5. Polymer concrete handholes and boxes with polymer concrete cover.
6. Utility structure accessories.

1.3 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
 1. Two or more ducts installed in parallel, with or without additional casing materials.
 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include duct-bank materials, including spacers and miscellaneous components.
 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 3. Include accessories for manholes, handholes, boxes.

4. Include underground-line warning tape.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

- a. Include plans, elevations, sections, details, attachments to other work, and accessories.
- b. Include duct entry provisions, including locations and duct sizes.
- c. Include reinforcement details.
- d. Include frame and cover design and manhole chimneys.
- e. Include ladder details.
- f. Include grounding details.
- g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
- h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

- a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
- b. Include duct entry provisions, including locations and duct sizes.
- c. Include cover design.
- d. Include grounding details.
- e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C858.

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 according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Owner's written permission.
- B. Ground Water: Assume ground-water level is 36 inches (900 mm) below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 DUCT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carlon
 2. Cantex
 3. Atkore
 4. Pencil
- B. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
- C. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.2 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Utility Vault Company
 2. Old Castle
 3. Utility Concrete Products
 4. Christy Concrete Products
- C. Comply with ASTM C858 for design and manufacturing processes.
- D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- F. Cover Legend: Molded lettering, as indicated for each service.
- G. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.

- H. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - 1. Extension shall provide increased depth of 12 inches (300 mm).
 - 2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
- I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
- J. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
 - 1. Center window location.
 - 2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - 3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
 - 4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 - 5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.3 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Oldcastle
 - 2. Armormorcast
 - 3. Quazite (Hubbell),
 - 4. Newbasis
- B. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, as indicated for each service.
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.4 UTILITY STRUCTURE ACCESSORIES

- A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.
- B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
 - 1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A48/A48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches (725 mm).
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 - 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C387, Type M, may be used.
 - b. Seal joints watertight using preformed plastic or rubber complying with ASTM C990. Install sealing material according to sealant manufacturers' written instructions.
- C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
- D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.
- E. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.
 1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- G. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
- I. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with provisions to connect to other sections to form a continuous unit, with minimum of nine holes for arm attachment.
 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.
- J. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- K. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater. Two required.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C1037.

- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 2. 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 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- C. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- E. Stub-ups and horizontal bends: Concrete-encased PVC-coated GRC.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 36 inches, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
 1. Grout end bells into structure walls from both sides to provide watertight entrances.
- F. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.
 1. Begin change from regular spacing to terminator spacing 10 feet (3 m) from the terminator, without reducing duct line slope and without forming a trap in the line.
- G. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- H. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- I. Pulling Cord: Install 200-lbf- (1000-N-) test nylon cord in empty ducts.
- J. Direct-Buried Duct and Duct Bank:
 1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
 2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
 3. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
 4. Set elevation of bottom of duct bank below frost line.
 5. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent movement. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 7. Install duct with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and communications duct.
 8. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

9. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
 - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups shall be flush with finished floor and minimum 3 inches (75 mm) from conduit side to edge of slab.
 - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups shall be flush with finished floor and no less than 3 inches (75 mm) from conduit side to edge of slab.
10. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
 - a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
- K. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

- A. Precast Concrete Handhole and Manhole Installation:
 1. Comply with ASTM C891 unless otherwise indicated.
 2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line, below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.

F. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

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

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).
- H. Grass area: Provide 8-inch thick by 12-inch wide concrete around handhole.

3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
 - 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 a 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. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump.
 - 1. Sweep floor, removing dirt and debris.
 - 2. Remove foreign material.

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SCHEMATIC DESIGN

END OF SECTION 260543

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraints - rigid type.
2. Restraints - cable type.
3. Restraint accessories.
4. Post-installed concrete anchors.
5. Concrete inserts.

B. Related Requirements:

1. Section 260500 "Common Work Results for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 COORDINATION

A. Tests and Inspections:

1. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and provide notice at least seven days in advance.
2. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
3. 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 an agency acceptable to authorities having jurisdiction.
4. Annotate to indicate application of each product submitted and compliance with requirements.

- B. Delegated Design Submittal, signed and sealed by qualified structural professional engineer, for Each Seismic-Restraint Device:
 - 1. For each seismic-restraint device, including restraint - rigid and cable type, restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on 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 loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
 - 2. Seismic-Restraint Detail Drawings prepared by qualified structural professional engineer:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to 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.
 - 3. Product Listing, Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified structural professional engineer to design seismic control system.
- B. Seismic-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to 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: an agency acceptable to authorities having jurisdiction.

- C. Consequential Damage: Provide additional seismic restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component does not cause failure of any other essential building component.
- D. Fire/Smoke Resistance: Seismic-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 and labeled by an NRTL in accordance with ASTM E84 or UL 723.
- E. Component Supports:
 - 1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of an NRTL.

2.2 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line; Eaton, Electrical Sector.
 - 2. CADDY; nVent.
 - 3. California Dynamics Corporation.
 - 4. Hilti, Inc.
 - 5. Isolation Technology, Inc.
 - 6. TOLCO.
 - 7. Unistrut; Atkore International.
 - 8. Vibration Mountings & Controls, Inc.
- B. Description: 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.

2.3 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line; Eaton, Electrical Sector.
 - 2. CADDY; nVent.
 - 3. Loos & Co.
 - 4. Vibration Mountings & Controls, Inc.
- B. Seismic-Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-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.

- C. 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.

2.4 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line; Eaton, Electrical Sector.
 - 2. CADDY; nVent.
 - 3. Hilti, Inc.
 - 4. Loos & Co.
 - 5. Mason Industries, Inc.
 - 6. TOLCO.
 - 7. Unistrut; Atkore International.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Atkore International.

2. 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. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line; Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Atkore International.
2. 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.

C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW) that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.6 CONCRETE INSERTS

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

1. B-line; Eaton, Electrical Sector.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Powers Fasteners.
5. Simpson Strong-Tie Co., Inc.
6. Unistrut; Atkore International.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.

- C. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC-RESTRAINT DEVICES

- A. Provide seismic-restraint devices for systems and equipment where indicated in Equipment Schedules or Seismic Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to 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.
- 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 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 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 devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Equipment and Hanger Restraints:
 - 1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- G. Install cables so they do not bend across edges of adjacent equipment or building structure.
- H. 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.
- I. 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.
- J. 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 is to 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.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.

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

C. Prepare test and inspection reports.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for conductors and cable.
 - 2. Underground-line warning tape.
 - 3. Equipment identification labels.

1.3 SUBMITTALS

- A. Product Data: For warning tape.
- B. Sample: Submit sample for typical panelboard label.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND -CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.3 EQUIPMENT IDENTIFICATION LABELS

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- B. Stenciled Legend: In nonfading, waterproof, ink or paint, black letters on white background or white letters on black background. Minimum letter height shall be 1 inch (25 mm).
- C. Labels for panelboards shall identify panelboard designation, voltage, phase and source of panelboard feeder.
- D. Labels for safety switches shall identify load served.
- E. Labels for transformers shall identify transformer designation.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Raceways of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands or snap-around, color-coding bands:

1. Fire Alarm System: Red.
 2. Security System: Blue and yellow.
 3. Telecommunication System: Green and yellow.
- B. Junction Boxes for feeders and branch circuits: Provide label indicating panelboard and circuit number. Labels may be machine printed or handwritten with a permanent marker.
1. Place label on outside of box cover in unfinished spaces and where concealed above finished ceilings, access panels, etc.
 2. Place label on inside of box cover where box is exposed in a finished space.
- C. Junction Boxes for Fire Alarm Systems: Provide red coverplates or paint coverplates red in the field.
- D. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list future load (if known), source and circuit number. Where located in an unfinished space or concealed in an accessible space above finished ceiling, label cover with permanent marker or adhesive label.
- E. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for direct-buried cables, cables in raceway, and empty raceway.
- F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Where required by NEC or local codes comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
- G. Provide labels for the following equipment unless noted otherwise:
1. Panelboards:
 - a. Provide label on exterior of panelboard above panelboard door.
 - b. Provide typed directory. The directory shall reflect final room numbers as assigned by the Owner, which may not match room numbers indicated on construction document drawings. Install directory in a metal frame or plastic pouch mounted on the inside cover of the panelboard.
 2. Load Centers:
 - a. Provide label on exterior of load center where installed in an unfinished space. For load centers installed in a finish space, identify load center designation on the typed directory (see below) and do not provide a label. Install directory in a metal frame or plastic pouch mounted on the inside cover of the load center.
 - b. Provide typed directory. The directory shall reflect final room numbers as assigned by the Owner, which may not match room numbers indicated on construction document drawings.
 3. Switchboards:
 - a. Provide labels for switchboards.

- b. Provide a label for each branch switch or breaker identifying the load served.
 - 4. Transformers.
 - 5. Motor-Control Centers:
 - a. Provide label for motor control centers indicating all information required for panelboards, i.e. equipment designation, voltage, source, etc
 - b. Provide a label for each branch switch or breaker identifying the load served.
 - 6. Disconnect switches:
 - a. Provide labels for heavy duty safety switches, combo disconnect starters and enclosed controllers.
 - b. Labels are not required for motor rated toggle switches or switches with thermal overloads.
 - 7. Enclosed circuit breakers.
 - 8. Motor starters:
 - a. Label shall identify the load served.
 - 9. Power transfer equipment.
 - 10. Contactors.
- H. Provide labels for the following devices unless noted otherwise:
- 1. Receptacles:
 - a. Provide label for receptacle on receptacle wall plate that indicates the panel and circuit served from.
 - b. Label shall be made by electronic labeler Dymo-Tape, or approved equal.
 - I. Provide additional identification as required by NEC or local codes.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.

2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - f. Isolated Ground: Green with yellow stripe.
 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Ground: Green.
 4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- F. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- G. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 4 to 6 inches (100 to 150 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.

END OF SECTION 260553

SECTION 260573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- F. SCCR: Short-circuit current rating.
- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

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

2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Short-circuit study input data, including completed computer program input data sheets.
 - b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - 1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - 2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 1. For Power Systems Analysis Software Developer.
 2. For Power System Analysis Specialist.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
 1. For overcurrent protective devices to include in emergency, operation, and maintenance manuals.
 2. The following are from the Short-Circuit Study Report:
 - a. Final one-line diagram.
 - b. Final Short-Circuit Study Report.
 - c. Short-circuit study data files.
 - d. Power system data.

1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.

1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. EasyPower, LLC (formerly ESA Inc.).
 2. Power Analytics, Corporation.
 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 399 and IEEE 551.
1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.

6. Derating factors and environmental conditions.
 7. Any revisions to electrical equipment required by the study.
- D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- E. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data:
1. One-line diagram of system being studied.
 2. Power sources available.
 3. Manufacturer, model, and interrupting rating of protective devices.
 4. Conductors.
 5. Transformer data.
- G. Short-Circuit Study Output Reports:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.

- 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
 1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Architect's attention.
 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.
 3. Power sources and ties.
 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
 7. Motor horsepower and NEMA MG 1 code letter designation.

8. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
9. Derating factors.

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
 1. To normal system low-voltage load buses where fault current is 10 kA or less.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include the ac fault-current decay from induction motors and synchronous motors and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 260573.13

SECTION 260573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power System Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- F. SCCR: Short-circuit current rating.
- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

- A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

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

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

1.6 CLOSEOUT SUBMITTALS

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

1. The following are from the Coordination Study Report:
 - a. Final one-line diagram.
 - b. Final protective device coordination study.
 - c. Coordination study data files.
 - d. List of all protective device settings.
 - e. Time-current coordination curves.
 - f. Power system data.

1.7 QUALITY ASSURANCE

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

- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications:
 - 1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. EasyPower, LLC (formerly ESA Inc.).
 - 2. Power Analytics, Corporation.
 - 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 - 1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
 - 6. Any revisions to electrical equipment required by the study.
 - 7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- D. Protective Device Coordination Study:
 - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, and ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Medium-voltage equipment overcurrent relays.
 - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.
 - g. Ground-fault protective devices.
 - h. Motor-starting characteristics and motor damage points.
 - i. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

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

- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Electrical power utility impedance at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus (three phase and line to ground).
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 11. Maximum demands from service meters.
 12. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
 13. Motor horsepower and NEMA MG 1 code letter designation.
 14. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
 15. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
 16. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Ratings, types, and settings of utility company's overcurrent protective devices.
 - e. Special overcurrent protective device settings or types stipulated by utility company.
 - f. Time-current-characteristic curves of devices indicated to be coordinated.
 - g. 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.

- h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
- i. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:
 - 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
 - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine

temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

- J. Include the ac fault-current decay from induction motors synchronous motors 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.
- K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- L. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Include in the report identification of any protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
 - 1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
 - 2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
 - 3. Prepare load-flow and 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.

3.5 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141 and voltage sags so as not to affect operation of other utilization equipment on system supplying the motor.

3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

END OF SECTION 260573.16

SECTION 260573.19 - ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.
- D. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- E. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- F. SCCR: Short-circuit current rating.
- G. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- H. Single-Line Diagram: See "One-Line Diagram."

1.4 ACTION SUBMITTALS

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

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

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For Power Systems Analysis Software Developer.
 - 2. For Power System Analysis Specialist.
 - 3. For Field Adjusting Agency.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.

2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. EasyPower, LLC (formerly ESA Inc.).
 2. Power Analytics, Corporation.
 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram, showing the following:
 1. Protective device designations and ampere ratings.
 2. Conductor types, sizes, and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
 4. Motor designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
- D. Study Input Data: As described in "Power System Data" Article.

- E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- G. Arc-Flash Study Output Reports:
 - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
 - 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Restricted approach boundary.
 - 6. Limited approach boundary.
 - 7. Working distance.
 - 8. Incident energy.
 - 9. Hazard risk category.
 - 10. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
- B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
 - 1. Location designation.
 - 2. Nominal voltage.
 - 3. Protection boundaries.

- a. Arc-flash boundary.
 - b. Restricted approach boundary.
 - c. Limited approach boundary.
 - 4. Arc flash PPE category.
 - 5. Required minimum arc rating of PPE in Cal/cm squared.
 - 6. Available incident energy.
 - 7. Working distance.
 - 8. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
 - 2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
 - 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
- D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations.
- F. Calculate the limited, restricted, and prohibited approach boundaries for each location.

- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
 - 1. Fault contribution from induction motors shall not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors shall be decayed to match the actual decrement of each as closely as possible.
- H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the arc-flash hazard analysis.
 - 1. Verify completeness of data supplied on one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Architect's attention.
 - 2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.
 - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:
 - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Obtain electrical power utility impedance or available short circuit current at the service.
 - 3. Power sources and ties.
 - 4. Short-circuit current at each system bus (three phase and line to ground).
 - 5. Full-load current of all loads.
 - 6. Voltage level at each bus.

7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
11. Busway manufacturer and model designation, current rating, impedance, lengths, size, and conductor material.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
14. Medium-voltage conductor sizes, lengths, conductor material, conductor construction and metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).

3.4 LABELING

- A. Apply arc-flash label on the front cover of each section of the equipment for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.
- B. Each piece of equipment listed below shall have an arc-flash label applied to it:
 1. Low-voltage switchboard.
 2. Switchgear.
 3. Medium voltage transformers
 4. Low voltage transformers
 5. Panelboard and safety switch over 250 V.
 6. Applicable panelboard and safety switch under 250 V.
 7. Control panel.
- C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.
 1. Indicate arc-flash energy.
 2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

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

3.6 DEMONSTRATION

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

LOCKHART PRE K-8 SCHOOL
VIRGIN ISLANDS DEPARTMENT OF EDUCATION (VIDE)
ST. THOMAS, US VIRGIN ISLANDS

68-21103-13
SCHEMATIC DESIGN

END OF SECTION 260573.19

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes Cx process requirements for the following electrical components, systems, assemblies, and equipment:
 - 1. Electrical equipment connected to Normal power systems, including the following:
 - a. Transformers.
 - b. Primary and secondary service electrical systems.
 - c. Distribution and branch-circuit panelboards.
 - d. Lightning protection systems.
 - e. Grounding systems.
 - 2. Electrical equipment connected to Essential power systems that provide an alternative source of power in the absence of power from the Normal power system, including the following:
 - a. Primary and secondary service electrical systems.
 - b. Distribution and branch-circuit panelboards.
 - c. Grounding systems.
 - d. UPS.
 - 3. Controls and instrumentation, including the following:
 - a. Equipment monitoring systems.
 - b. PV and BESS control systems.
 - c. Electrical metering and metering system.
 - d. Lighting control systems.
 - e. Security systems.
 - f. Fire-alarm systems.
 - g. Battery Back-up System.
 - 4. Systems testing and verification, including Normal and Essential power systems, and transitions from Normal to Essential power systems and back.
- B. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.

1.3 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. Essential Power Systems: A power system that a facility transitions to in the absence of Normal power. This power includes all systems classified as "standby" or "emergency," including "legally required."
- E. Low Voltage: 600 V and below.
- F. Medium Voltage: 601 V and above.
- G. Normal Power Systems: A power system that provides primary power to a facility.
- H. OPR: Owner's Project Requirements, as defined in Section 019113 "General Commissioning Requirements."
- I. "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.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For BAS and electrical testing technician.
- B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.
 - 1. Instrumentation and control for electrical systems.
 - 2. Instrumentation and control for lighting control systems.
 - 3. Liquid-filled transformers.
 - 4. Dry-type transformers.
 - 5. Switchgear and switchboard assemblies rated 1200 A or greater.
 - 6. Low-voltage motor starters.
 - 7. Low-voltage surge protective devices.
 - 8. Metering devices.
 - 9. Low-voltage power circuit breakers.
 - 10. Grounding systems.
 - 11. Ground-fault protection systems.
 - 12. Panelboards.
 - 13. Variable-frequency drives.
 - 14. Backup emergency power supply systems.
 - 15. Battery chargers.

16. VRLA batteries.
17. UPS systems.
18. Lighting.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electrical systems and components to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Testing Technician Qualifications: Technicians to perform electrical 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. Vocational school four-year-program graduate or an Associate's degree in electrical systems, or similar field. Degree may be offset by three years' experience as an apprentice or a journey-level electrician. Generally, required knowledge includes electrical and HVAC&R concepts, building operations, and application and use of tools and instrumentation to measure performance of electrical equipment, assemblies, and systems.
 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. 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 shall 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.
- 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, 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 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)."

3.2 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 shall 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 technicians, 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.

3.3 Cx TESTS FOR ELECTRICAL SYSTEMS

A. Verification of Normal Power System Operation:

1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal power system.
2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Normal power system.
4. Test Conditions: Energize components of Normal power system, one at a time.
5. Acceptance Criteria: Proper operation of Normal power system over a 24 hour period.

B. Verification of Essential Power System Operation:

1. Prerequisites:
 - a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential power system.
 - b. Completion of "Verification of Normal Power System Operation" tests.
2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Essential power system.
4. Test Conditions:
 - a. Energize components of Normal power system.
 - b. Simulate a failure of Normal power system.
5. Acceptance Criteria: Transfer of power from Normal to Essential power system within OPR.

C. Verification of Control and Instrumentation:

1. Prerequisites: Acceptance of results for construction checklists.
 - a. Section 260923 "Lighting Controls – Wired, Networkable"
 - b. Section 262713 "Electricity Metering."

D. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential power systems.

E. Test Conditions:

1. Energize components of Normal power system.
2. Test operation of equipment.

F. Acceptance Criteria: Operation of equipment according to OPR.

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68-21103-13
SCHEMATIC DESIGN

END OF SECTION 260800

SECTION 260923 – LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Description: Work includes an integrated, networked, energy-saving lighting control system including lighting control panels, occupancy sensors, emergency lighting transfer devices, daylighting controls, and associated appurtenances. System shall be designed and operate such that all lighting fixtures will be controlled in compliance with the IECC 2021 edition.
- B. General Requirements: Drawings and general provisions of the Contract, including General Conditions and Division 01 sections apply to Work in this section.

1.2 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with applicable city, county, and state codes and ordinances.
- B. Codes and Standards:
 - a. NFPA 70, National Electrical Code (NEC).
 - b. UL 508, Standard for Industrial Control Panels.
 - c. UL 916, Standard for Energy Management Equipment.
 - d. UL 917, Standard for Clock Operated Switches.
 - e. UL 924, Standard for Emergency Lighting and Power Equipment.
 - f. 47 CFR, Subparts A and B, for Class A digital devices.
 - g. 2021 International Energy Conservation Code (IECC)
- C. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- D. Comply with NEC, NEMA, and FCC emission requirements for Class A applications.
- E. Electrical Subcontractor is responsible for confirming components and sensors interoperate as a single system and are applicably compatible.
- F. Certification: Manufacturer shall certify that products will meet product specifications and local energy codes. If any additional equipment is required to meet coverage patterns and local energy codes, provide additional equipment at no additional cost to the Owner.
- G. Control Intent – Control Intent includes, but is not limited to:
 - a. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.

- b. Initial sensor and switching zones
- c. Initial time switch settings

1.3 SYSTEM DESCRIPTION & OPERATION

- A. The Lighting Control and Automation system as defined under this section covers the following intelligent lighting control devices:
 - 1) Digital Lighting Control Relay Panels
 - 2) Digital Lighting Room Controllers
 - 3) Digital Occupancy/Vacancy Sensors
 - 4) Digital Photocells
 - 5) Digital Wall Switches
 - 6) Digital Plug Load Controllers
 - 7) Digital Area Controller (BACNET, Ethernet interface(s))
 - 8) Inter-device wiring (Category 5, etc.)
 - 9) Emergency lighting control (UL 924) devices.
- B. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.
- C. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure shall be permissible to minimize overall device count of system.
- D. Intelligent lighting control devices shall communicate digitally and possesses at least two RJ-45 connectors.
- E. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher-level network backbone.
- F. Devices within a lighting control zone shall be connected with low voltage cabling, in a daisy-chain fashion, and in any order.
- G. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.
- H. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.
- I. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone. Standalone “bus power supplies” shall not be required in all cases.

- J. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.
- K. System shall have a primary wall mounted network control “gateway” device that is capable of accessing and controlling connected system devices and linking into an Ethernet LAN.
- L. System shall use “bridge” devices that route communication and distribute power for up to 8 lighting zones together for purposes of decreasing system wiring requirements.
- M. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.
- N. Individual lighting zones shall be capable of being segmented into several channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.
- O. System shall be capable of operating a lighting control zone according to several sequences of operation. Note operating modes should be utilized only in manners consistent with local energy codes.
 - a. Auto-On / Auto-Off (via occupancy sensors)
 - b. Manual-On / Auto-Off
 - c. Auto-to-Override On
 - d. Manual-to-Override On
 - e. Auto On/Predictive Off
 - f. Multi-Level On (multiple lighting levels per manual button press)
- P. Control software shall enable logging of system performance data and presenting useful information in a web-based graphical format and downloadable to .CSV files.
- Q. Control software shall enable integration with a BMS via BACNET IP.
- R. System shall provide the option of having pre-terminated plenum rated CAT-5 cabling supplied with hardware.
- S. System programming shall be done in the following fashion:
 - a. For completely networked systems, system programming and control adjustments can be done via software from a single point in the network.
 - b. For stand-alone systems, programming shall be done by hand held remote control or by software app via standard wireless protocol such as wifi or Bluetooth.

T. System Architecture:

- a. Lighting in classrooms, offices, conference rooms, multi-purpose rooms, and rooms of similar size and function: Utilize intelligent room controllers in conjunction with intelligent sensors and switches to meet design intent and code required lighting control

for the space. An auxiliary contact to trigger occupied/unoccupied modes for mechanical system shall be provided either integral to the occupancy sensor or as an additional unit connected to the system. Unless noted otherwise, all 0-10V wiring to dimmable fixtures shall be connected between fixtures and intelligent room controllers. All room controllers shall be networked together and ultimately connected to the BMS via BACNET interface. System shall receive timing commands from the BMS system.

- b. Lighting in central spaces and large spaces such as corridors, gymnasiums, and lunchrooms: Utilize intelligent lighting relay panels, with 0-10V dimming outputs in conjunction with intelligent sensors and switches to meet design intent and code required lighting control for the space. Unless noted otherwise, all 0-10V wiring to dimmable fixtures shall be connected between interior lighting fixtures and relay panel. All relay panels shall be networked together and connected to the BMS via BACNET interface. System shall receive timing commands from the BMS system.
- c. Exterior Lighting: Utilize intelligent lighting relay panels to meet design intent and code required lighting control. Dimming outputs and 0-10V wiring are required for exterior lighting to achieve IECC light output reduction requirements. All relay panels shall be networked together and connected to the BMS via BACNET interface.
- d. Small, regularly unoccupied spaces such as storage rooms, utility rooms (non-electrical), or janitor closets: Stand-alone wall box sensors may be used.

1.4 SUBMITTALS

- A. Comply with requirements in Division 01 and Section 260500.
- B. Product Data: Submit manufacturer's technical product data and maintenance data for each type of lighting control system and components.
- C. Shop Drawings:
 - a. Floor plans and reflected ceiling plans showing occupancy and daylighting sensor locations. Include typical mounting details for occupancy and daylighting sensors.
 - b. Detailed point to point wiring diagrams.
 - c. System diagrams showing contactor panels, number and type of switches and sensors, low voltage switches, and building energy management system computer.
 - d. Wiring schedules.
 - e. Typical wiring diagrams for each component.
 - f. Provide sequence of operations for each space type in a format suitable for programming requirements of the specific system and meeting the intent of the sequence of operation provided by the architect/engineer.
- D. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On a USB Thumb drive or compact disc, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens

E. Test Reports:

- a. Field test reports.
- b. Submit completed copy of reports and include copy in the Operation and Maintenance Manual.

1.5 WARRANTY

- A. Provide a five-year complete manufacturer's warranty on all products to be free of manufacturers' defects.

1.6 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revise licenses for use of the software.
- a. Provide 30-day notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment, if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers and specific product line offering products that may be incorporated into the Work include one of the following, or an approved equal:
- 1) nLight, an Acuity Brand Company – nLight Control System.
 - 2) Wattstopper, - Digital Lighting Management.
 - 3) Hubbell Lighting Controls – NX Distributed Intelligence
- B. Approved manufacturer controls products may have different wiring methods, ballast/ driver, occupancy sensor, and photosensor requirements than what is shown on the electrical drawings. Contractors are required to familiarize themselves with all required wiring, additional part and pieces, necessary ballasts/ drivers, required installation labor, etc. to provide for a complete installed system that meets the intent and functionality of the specified system. The Contractor shall provide as part of the shop drawing submittals, complete lighting drawings including all wiring, equipment, equipment locations, etc. for the submitted system. All costs shall be included in the bid for a complete operational system that meets the specified and designed system.

2.2 COMPONENTS

- A. Components listed in this section are intended to best represent typical components of the digital intelligent lighting control system. System components may vary slightly between manufacturers.
- B. INTELLIGENT LIGHTING ROOM CONTROLLER
 - a. Room Controller(s) to control the quantity of lighting required. Lighting control unit may consist of a single, multiple output unit or multiple, single output units combined together to provide required number of switching and dimming zones.
 - b. Unless indicated otherwise, the room controller shall provide 0-10 volt dimming capability for the required number of dimmable lighting loads.
 - c. The room controller shall integrate the functionality of connected control components including wall switch stations, occupancy sensors and daylight sensors to provide the required sequence of operation for the space.
 - d. Room controllers and associated room control components shall be networked but be capable of operating in a totally stand-alone mode and not require the use of a network, software, computer or server for local control functions.
 - e. Relays shall be sized appropriately for the loads served.
 - f. Control unit shall install onto a standard junction box, either as a cover to the box or through knockout via nipple attachment.
 - g. Switched receptacles in spaces controlled by intelligent lighting room controllers shall be controlled via room controller plug load room controllers. Each switched circuit shall have a dedicated relay to allow for programming flexibility and to limit the effect of a faulty relay or receptacle.
- C. LIGHTING CONTROL RELAY PANELS
 - a. Panels shall be configured with the quantity of relays and 0 - 10 volt dimming channels as indicated.
 - b. Provide capacity for 8, 16, 24, 32, or 48 relays in each panel as indicated.
 - c. Panel shall incorporate normally closed latching relays capable of switching 120/277 VAC loads.
 - d. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
 - e. Relays shall have a minimum Short Circuit Current Rating (SCCR) of 14,000A
 - f. Panel shall power itself from an integrated 120/277 VAC supply.
 - g. Panel shall be capable of operating as either two networked devices or as one.
 - h. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
 - i. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connections.
 - j. Dimming channels shall be assignable to control zones as required via the control software.
 - k. Dimming channels shall be configurable to respond to manual raise/lower wall switch control stations, preset scenes, or daylight harvesting photocells.
 - l. Switched receptacles in spaces controlled by lighting control relay panels shall be controlled via relay panels. Each switched circuit shall have a dedicated relay to allow for programming flexibility and to limit the effect of a faulty relay or receptacle.

D. NETWORK COMMUNICATION BRIDGES

- a. Device shall surface mount to a standard 4" x 4" square junction box.
- b. Device shall have a minimum 4 RJ-45 ports.
- c. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway or central head end.
- d. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a low voltage cabled connection.
- e. Device shall be careful of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power.

E. AREA CONTROLLER

- a. The Area Controller shall have the ability to communicate by means of TCP/IP over Ethernet allowing enterprise connectivity between the Lighting Control System and external LAN or WAN networks.
- b. Provide integral capability to communicate with the Building Automation System via BACNET IP protocol.
- c. The Area Controller shall function as a web server allowing the user interface to be accessible through a standard web browser.
- d. The installation of software shall not be required. At a minimum, the user interface shall provide the following functions:
 - 1) Automatic discovery of system devices.
 - 2) Commissioning of devices into logical Areas and Zones,
 - 3) Display the entire system in a logical navigation tree view
 - 4) Allow the user to name Zones, Groups, Presets, Schedules and individual loads
 - 5) Set up control functions for system inputs and outputs.
 - 6) Monitor status and override individual relays and dimmers.
 - 7) Set up and download schedules to panels and room controllers
- e. Once programming is complete, any time-clock functionality in the Area controller shall be disabled to prevent conflicts with scheduling signals from the BMS system via BACNET.

F. OCCUPANCY/VACANCY SENSORS

- a. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
- b. Sensors shall be wall mounted or ceiling mounted.
- c. Sensors shall utilize Dual technology. Acceptable dual technology includes PIR/Microphonics or PIR/Ultrasonic.
- d. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors. RJ45 adapters may be used to allow standard analog sensors to be used.
- e. All sensors shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate of a potential wiring issue
- f. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with low voltage cabling.

- g. Include low voltage auxiliary relay (or additional I/O unit with equivalent functionality) to send occupied/unoccupied status to equipment by Div. 23. Coordinate with Div. 23 for wiring between auxiliary relay and Div 23 controls.
- h. Occupancy/vacancy sensor may be incorporated into low voltage switch station in smaller rooms where sensor coverage is adequate for the given space.

G. DAYLIGHT (PHOTOCELL) SENSORS

- a. The daylight sensor shall provide ambient light level information to the intelligent room controller allowing daylight responsive lighting control.
- b. The system shall operate in a closed loop sequence of operation reducing the amount of electric light as the quantity of daylight entering the room increases.
- c. It shall be possible to configure multiple daylight zones in a room with open loop sensors. Each zone shall be programmable to proportionally respond to the light level provided by the daylight sensor.
- d. The daylight sensor shall be mounted and positioned to provide an unobstructed view of the windows per the manufacturer's directions.

H. LOW VOLTAGE SWITCH STATIONS

- a. Low voltage digital wall switch stations shall be of the programmable type using standard Cat5 cabling for connection to system.
- b. Stations shall have one to six buttons and provide lighting control functions as called out and shown on the plans.
- c. All switches shall be single gang and be of the generic decorator style allowing easy ganging and use of a wide array of standard wall switch plate options.
- d. Provide two RJ-45 ports per switch to allow for daisy chain connection of up to eight switches to each smart port.
- e. Switch station color shall match the device colors as specified in section 262726 - Wiring Devices.
- f. Switches buttons shall have engraved or printed text to clearly indicate function of button. Multi button scene switches shall have the names of the scenes listed as specified by the architect/engineer.

I. CONTROL SYSTEM PROGRAMMING KIT

- a. Provide (2) programming kits, each containing one of the following as required by the lighting control system:
 - 1) Hand Held remote.
 - 2) Bluetooth dongle with RJ45 connector for app based programming.

J. STAND ALONE WALL SWITCH VACANCY/ OCCUPANCY SENSORS

- a. Wall switch mounted dual technology motion sensor constructed of high-impact injected molded plastic.
- b. Digital architecture using two ultrasonic transmitters and two narrow bandwidth receivers.
- c. The sensor shall operate in high sensitivity and miser modes.

- d. The sensor shall self-adjust ultrasonic and infrared sensitivity, timer and air current compensation.
- e. The sensor shall provide visual status reporting.
- f. Mounting yoke shall be metal, no plastic.
- g. The sensor shall include override buttons, button count shall match what is shown on the drawings.

K. MANAGEMENT SOFTWARE

- a. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.
- b. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current occupancy sensor status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).
- c. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
- d. A printable network inventory report shall be available via the software.
- e. A printable report detailing all system profiles shall be available via the software.
- f. Software shall require all users to login with a User Name and Password.
- g. Software shall provide at least three permission levels for users.
- h. All sensitive stored information and privileged communication by the software shall be encrypted.
- i. All device firmware and system software updates must be available for automatic download and installation via the internet.
- j. Software shall be capable of managing systems interconnected via a WAN (wide area network)

L. CAT-5 CABLING

- a. All CAT-5 cabling for intra-room connectivity of control devices (example, between power packs and from power packs to sensors and switches) shall be pre-manufactured and provided by controls manufacturer.
- b. Field prepared cables may be used in the following situation
 - 1) Long cable lengths (ex. Between relay panels) or other cabling where the standard available lengths would provide a significant excess or shortage of cable.

- 2) Instances, if any, where cabling will have to be pulled in conduit, and pulling a terminated cable will add excessive difficulty and/or risk damaging the cable.

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Verify installation conditions as satisfactory to receive work of this section. Do not install until unsatisfactory conditions are corrected. Beginning work constitutes acceptance of conditions as satisfactory.

3.2 PREPARATION

- A. Field Measurements: Field verify locations of new and existing work prior to commencing work of this section.
- B. Protection: Protect surrounding areas and surfaces to preclude damage from work of this section.

3.3 PRE-INSTALLATION COORDINATION

- A. Pre-submittal meeting - Around the time of the shop drawings submittal, before the submittal is accepted, the General Contractor shall organize a coordination meeting to discuss the specifics of the lighting control design intent, sequence of operation, and specifics of the selected lighting control system to ensure that all appropriate parties are knowledgeable of the install and to make any last minute adjustments to the system or sequence of operation. This meeting shall include the lighting designer, General contractor, Electrical Contractor, Lighting Control System Manufacturer or Manufacturer Representative, and representative(s) from the School District Maintenance Group.
- B. Pre-installation training – Lighting Control System Manufacturer or Manufacturer Representative shall provide up to one day of installation training to Electrical Contractor and Representatives from the School District Maintenance Group prior to installation and rough-in of lighting control system. This meeting shall be organized by the electrical contractor.

3.4 INSTALLATION, APPLICATION, ERECTION, AND PERFORMANCE

- A. General: Install, apply, erect, and perform the work in accordance with Article “Quality Assurance” provisions, specifications, and manufacturer’s installation instructions and directions. Where these may be in conflict, the more stringent requirements govern.
- B. Provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements.

- C. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.
- D. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
 - a. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
 - b. Sequence of operation, (e.g. manual ON, Auto OFF. etc.).
- E. Open cabling methods may be utilized above accessible ceilings for Class 2 wiring. All cabling in exposed areas, above inaccessible ceilings and in walls shall be installed in raceway.

3.5 SEQUENCE OF OPERATION

- A. The settings shown in this paragraph and any additional information shown on the drawings shall be finalized at the pre-submittal meeting.
- B. Occupancy Sensor Settings
 - a. Ceiling and wall mount occupancy/vacancy sensor time delay settings:
 - 1) Classrooms – Shall be adjusted to 15 minutes.
 - 2) Public/ Student Restroom – Shall be adjusted to 15 minutes.
 - 3) Corridors - Shall be adjusted to 10 minutes.
 - 4) Offices/ Conference Rooms - Shall be adjusted to 15 minutes.
 - 5) Work/ Storage/ Custodial Spaces - Shall be adjusted to 5 minutes.
- C. Interior Daylighting (photocell) sensor settings:
 - a. Interior Daylight Sensor Light Level Settings:
 - 1) General classrooms – 35 footcandles
 - 2) Corridors – 30 footcandles
 - 3) Offices and conference rooms – 35 footcandles
 - 4) Gym – 40 footcandles
 - 5) Specialty classrooms – 55 footcandles
 - 6) Music classrooms – 50 footcandles
 - b. Lighting control system manufacturer, or a designated representative thereof, is to include field verification and adjustment of all photocells to achieve settings above.

3.6 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section 260553 "Electrical Identification".
- B. Identify controlled circuits in lighting contactors. Install permanent schedule inside enclosure.

- C. Provide engraved nameplate to identify time switches and/ or contactors with a unique designation.
- D. Factory-engage all lighting control switches with the function/scene of each button.

3.7 FIELD QUALITY CONTROL

- A. System Startup: Manufacturer's authorized technician shall confirm proper installation and operation of system components. Start-up requirement shall verify:
 - a. Lighting controls are located, installed, and adjusted as required by the factory and the Contract Documents for each room.
 - b. Operational Test: Verify operation of each lighting control device. Measure light levels throughout the room with a grid spacing of no greater than five foot on center and adjust each photo sensor to confirm uniform light levels are in compliance with values listed in the sequence of operations listed in the contract drawings. Adjust time delays are in compliance with values listed in the sequence of operations listed in the contract drawings.
 - c. Lighting controls function as a complete and operational system to meet requirements of the Energy Code and the Contract Documents.
- B. Manufacturer shall submit test documentation for each room including light level grid showing light levels and time delay test results and a written statement verifying that system meets above requirements. Include copy of test reports in the Operation and Maintenance Manual.

3.8 TRAINING

- A. Manufacturer's authorized technician shall train the Owner's personnel in operation, programming, and maintenance of lighting control systems and devices.

3.9 FACTORY COMMISSIONING

- A. Factory authorized representative will be available for a pre-wiring meeting to review submittal drawings, recommended wiring practices and programing requirements.
- B. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system. Provide no-less than three weeks' notice to schedule a start-up visit. Several business days may be required to confirm dates and times.
- C. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.
- D. Upon completion of the system commissioning the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

- E. Re-commissioning – After 30 days from occupancy re-calibrate all sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.
- F. Additional training - after 6 months, but not more than 1 year, a factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

3.10 COMMISSIONING

- A. Selected Division 26 equipment and systems referenced are to be commissioned per requirements of the most current adopted version of the International Energy Conservation Code.

END OF SECTION 260923

SECTION 261219 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.3 DEFINITIONS

- A. BIL: Basic Impulse Insulation Level.
- B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."
- D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).
- E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
- F. Elbow Connector: See "bushing elbow" above.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.

1. Include plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include single-line diagram.
4. Include list of materials.
5. Include nameplate data.
6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:
 1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
- B. Qualification Data: For testing agency.
- C. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For transformers, signed by product manufacturer.
- E. Source quality-control reports.
- F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with IEEE C2.
- C. Comply with IEEE C57.12.00.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."
 2. Component Importance Factor: 1.5.
 3. Component Amplification Factor: 1.0.
 4. Component Response Modification Factor: 2.5.
- B. Windings Material: Aluminum or Copper.
- C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.
- D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.
- E. Efficiency: Comply with 10 CFR 431, Subpart K.
- F. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.
- G. Tap Changer: External handle, for de-energized operation.
- H. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.

- I. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
- J. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- K. Insulating Liquids:
 - 1. Less-Flammable Liquids:
 - a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic, having passed the Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
- L. Sound level shall comply with NEMA TR 1 requirements.
- M. Corrosion Protection:
 - 1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.29, in manufacturer's standard color green.
 - 2. Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel according to ASTM A167, Type 304L, not less than No. 13 U.S. gage, complying with requirements of IEEE C57.12.29, standard color green.
 - 3. Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel according to ASTM A167, Type 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.29, in manufacturer's standard color green.

2.3 THREE-PHASE TRANSFORMERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Power Grids Division.
 - 2. Cooper Industries, Inc.
 - 3. Eaton.
 - 4. GE Power; General Electric Company.
- B. Description:
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with IEEE C57.12.26.
- C. Compartment Construction:

1. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.
- D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.
1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
 2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
 3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.
 4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
 5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.
- E. High-Voltage Section: Dead-front design.
1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
 2. Bushing inserts:
 - a. Conform to the requirements of IEEE 386.
 - b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.
 - c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.
 3. Bushing wells configured for loop-feed application.
 4. Access to liquid-immersed fuses.
 5. Dead-front surge arresters.
 6. Tap-changer operator.
 7. Load-Break Switch:
 - a. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL must match that of separable connectors, with continuous current rating and load-break rating of 200 A, and make-and-latch rating of 12 kA(rms sym). Switch operation must be as follows:
 - 1) Position I: Line A connected to line B and both lines connected to transformer.
 - 2) Position II: Transformer connected to line A only.
 - 3) Position III: Transformer connected to line B only.

- 4) Position IV: Transformer disconnected and line A not connected to line B.
- 5) Position V: Transformer disconnected and line A connected to line B.

8. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Capacities and Characteristics:

1. Power Rating (kVA): As indicated on plans.
2. Voltage Ratings: As indicated on plans.
3. Taps: Comply with IEEE C57.12.26 requirements.
4. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.
5. Minimum Tested Impedance (Percent at 85 deg C): 5.75.
6. K-factor: 1, complying with UL 1562.
7. Comply with FM Global Class No. 3990.

H. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.
8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with seal-in delay.

2.4 SERVICE CONDITIONS

A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following:

1. Altitudes above 3300 feet (1000 m).
2. Cooling air temperature exceeds limits.
3. Excessive load current harmonic factor.
4. Operation above rated voltage or below rated frequency.
5. Exposure to explosive environments.
6. Exposure to fumes, vapors, or dust.
7. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
8. Exposure to seismic shock or to abnormal vibration, shock, or tilting.

9. Exposure to excessively high or low temperatures.
10. Unusual transportation or storage conditions.
11. Unusual grounding resistance conditions.

2.5 WARNING LABELS AND SIGNS

- A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
 1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch- (50-mm-) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
 2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

2.6 SOURCE QUALITY CONTROL

- A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.
 1. Perform the following factory-certified routine tests on each transformer for this Project:
 - a. Resistance.
 - b. Turns ratio, polarity, and phase relation.
 - c. Transformer no-load losses and excitation current at 100 percent of ratings.
 - d. Transformer impedance voltage and load loss.
 - e. Operation of all devices.
 - f. Lightning impulse.
 - g. Low frequency.
 - h. Leak.
 - i. Transformer no-load losses and excitation current at 110 percent of ratings.
 - j. Insulation power factor.
 - k. Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
 - l. Induced potential.
 - m. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
 - n. Ratios on rated voltage connection and at tap extreme connections.
 - o. Polarity and phase relation on rated voltage connection.
 - p. No-load loss at rated voltage on rated voltage connection.
 - q. Exciting current at rated voltage on rated voltage connection.
 - r. Impedance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.
2. Remove a sample of insulating liquid according to ASTM D923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:
 - a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
 - b. Acid Neutralization Number: ASTM D974.
 - c. Interfacial Tension: ASTM D971.
 - d. Color: ASTM D1500.
 - e. Visual Condition: ASTM D1524.

H. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

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

3.2 INSTALLATION

- A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- B. Transformer shall be bolted to pad with approved stainless steel thru bolts.
- C. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.
- D. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
 - 2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 feet (3050 mm). Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
 - 3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 - 4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
 - 5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
 - 2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

- C. Terminate medium-voltage cables in incoming section of transformers according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

- A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
 - 1. General Field-Testing Requirements:
 - a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
 - b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 - c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
 - d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
 - e. Visual and Mechanical Inspection:
 - 1) Verify equipment nameplate data complies with Contract Documents.
 - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
 - a) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
 - f. Remove and replace malfunctioning units and retest.
 - g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.
 - 2. Medium-Voltage Surge Arrester Field Tests:
 - a. Visual and Mechanical Inspection:

- 1) Inspect physical and mechanical condition.
 - 2) Verify arresters are clean.
 - 3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
 - b. Electrical Test:
 - 1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
 - 2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
3. Liquid-Filled Transformer Field Tests:
 - a. Visual and Mechanical Inspection:
 - 1) Test dew point of tank gases if applicable.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify bushings are clean.
 - 4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
 - 5) Verify that liquid level in tanks is within manufacturer's published tolerances.
 - 6) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 7) Verify presence of transformer surge arresters and that their ratings are as specified.
 - 8) Verify that as-left tap connections are as specified.
 - b. Electrical Tests:
 - 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
 - 2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
 - 3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
 - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

- 5) Remove a sample of insulating liquid according to ASTM D923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D3612.

3.6 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
 4. Report:
 - a. Prepare a written report covering monitoring performed and corrective action taken.
- B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.
 1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.
 2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.
 3. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
 4. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261219

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 500 kVA.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Certification: Indicate that equipment meets project seismic requirements.

- B. Source quality-control reports.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
 - 1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.
- B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.
- C. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. Schneider Electric USA (Square D).
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. ABB (Electricification Products Division).
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2.3 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
- D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
 - 2. Grounded to enclosure.
- D. Coils: Continuous windings without splices except for taps.
 - 1. Coil Material: Aluminum or Copper.
 - 2. Internal Coil Connections: Brazed or pressure type.
 - 3. Terminal Connections: Welded.
- E. Enclosure: Ventilated.
 - 1. NEMA 250, Type 4X, Stainless Steel: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 3. Wiring Compartment: Sized for conduit entry and wiring installation.
- F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

- H. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature.
- J. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
 - 2. Indicate value of K-factor on transformer nameplate.
 - 3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.
- L. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- M. Wall Brackets: Where indicated on plan, wall brackets shall be fabricated from design drawings signed and sealed by a licensed structural engineer.

2.5 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
 - 1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
 - 2. Ratio tests at rated voltage connections and at all tap connections.
 - 3. Phase relation and polarity tests at rated voltage connections.
 - 4. No load losses, and excitation current and rated voltage at rated voltage connections.
 - 5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
 - 6. Applied and induced tensile tests.
 - 7. Regulation and efficiency at rated load and voltage.
 - 8. Insulation-Resistance Tests:
 - a. High-voltage to ground.
 - b. Low-voltage to ground.

- c. High-voltage to low-voltage.
- 9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
 - 2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection.
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 - 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.

- c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
 - C. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 - 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform power-factor or dissipation-factor tests on all windings.
 - d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - e. Perform an excitation-current test on each phase.
 - f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
 - D. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading. Remove and replace units that do not pass tests or inspections and retest as specified above.
 - E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Service and distribution switchboards rated 600 V and less.
 - 2. Surge protection devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
 - 7. Identification.

- B. Related Requirements

- 1. Section 260573.13 "Short-Circuit Studies" for selecting overcurrent devices
 - 2. Section 260573.16 "Coordination Studies" for adjustment of breakers
 - 3. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.
 - 4. Section 263100 "Photovoltaic and Battery Energy Storage System" for integration to grid/off grid control system.
 - 5. Section 262713 "Electricity Metering" for metering requirements.

1.3 ACTION SUBMITTALS

- A. Submit written Short Circuit and Coordination Studies, Arc-Flash Hazard Analysis and reports, as required by Section 260570 concurrently or prior to submittals required by this section.
- B. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
 - 1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- C. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail utility company's metering provisions with indication of approval by utility company.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

D. Delegated Design Submittals:

1. For arc-flash hazard analysis.
2. For arc-flash labels.
3. For Short Circuit Studies
4. For Coordination Studies

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

- a. Routine maintenance requirements for switchboards and all installed components.
- b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install integral, permanent electric heating to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

1.10 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Three years from date of Substantial Completion.
- B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB (Electrification Products Division).
 - 2. Eaton.
 - 3. Schneider Electric USA (Square D).
 - 4. Siemens Industry, Inc., Energy Management Division.
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

- C. 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.
- D. 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.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.
- H. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- I. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- J. Indoor Enclosures: Stainless steel, NEMA 250, Type 1.
- K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- L. Barriers: Between adjacent switchboard sections.
- M. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - 1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
 - 2. Space-Heater Power Source: Transformer, factory installed in switchboard.
- N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.
- O. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- P. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- Q. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.

2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - a. If bus is aluminum, use copper- or tin-plated aluminum for circuit-breaker line connections.
 - b. If bus is copper, use copper for feeder circuit-breaker line connections.
3. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
4. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
- R. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- S. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 SURGE PROTECTION DEVICES

- A. SPDs: Factory installed, integrally mounted, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
 1. UL 1449 3rd Edition Type 1 Device, 20kA nominal (L-N) rating.
 2. Minimum single-impulse current rating per phase shall be as follows:
 - a. Line to Neutral: 300,000A.
 - b. Line to Ground: 300,000A.
 3. Protection modes shall be as follows:
 - a. Line to neutral.
 - b. Line to ground.
 4. EMI/RFI Noise Attenuation per UL 1283: -50 dB at 100 kHz.
 5. Maximum UL 1449 Listed Voltage Protection Ratings (VPR's) shall not exceed the following:
 - a. 1200 V, line to neutral and line to ground on 277/480 V systems.
 - b. 2000 V, line to line on 277/480 V systems.
 6. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) shall not exceed the following:
 - a. 15%, allowable system voltage fluctuation on 277/480 V systems.
 - b. 320 V, MCOV on 277/480 V systems.
 7. Accessories:

- a. Audible alarm activated on failure of any surge diversion module.
 - b. Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.
 - c. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - d. Indicator light display for protection status.
- B. Protection modes and UL 1449 VPR for grounded wye circuits with [480Y/277 V] [208Y/120 V], three-phase, four-wire circuits shall not exceed the following:

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Provide Arc Energy Reducing Maintenance Switch on any breaker or fusible disconnect switch which can be adjusted 1,200 A or higher per NEC 240.87.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. Circuit breaker types, frame sizes, and functionality shall be as required to meet the overcurrent device selectivity requirements as noted in 26 05 73.16 Coordination Study, but as a minimum shall be:
- 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. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long and short time adjustments.
 - d. Ground-fault pickup level, time delay, and I squared t response.
 - 3. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical 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. Arc Energy Reducing Maintenance Switch on any breaker which can be adjusted 1,200 A or higher per NEC 240.87.
 - f. Motor operator where shown on drawings.
- C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
- 1. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 - 2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 - 3. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

4. Service-Rated Switches: Labeled for use as service equipment.

2.5 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
 1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary (unless metering requires digital protocol). Burden and accuracy shall be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
- B. Multifunction Digital-Metering Monitor: Coordinate with section 262713 "Electricity Metering" for metering requirements. Meters may be incorporated into the gear or in a separate enclosure. Provide factory installed CTs and PTs for external mounted meters.

2.6 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. 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.
- C. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented stainless steel box or cabinet. Arrange for wall mounting.
- D. 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.

2.8 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
 3. Protect from moisture, dust, dirt, and debris during storage and installation.
 4. Install temporary heating during storage per manufacturer's instructions.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 5. Install anchor bolts to elevations required for proper attachment to switchboards.
 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install filler plates in unused spaces of panel-mounted sections.

- G. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install spare-fuse cabinet.
- I. Comply with NECA 1.

3.3 CONNECTIONS

- A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- B. Support and secure conductors within the switchboard according to NFPA 70.
- C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 5. Perform the following infrared scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Switchboard will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip and monitoring units.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. **Submit written Short Circuit and Coordination Studies, Arc-Flash Hazard Analysis and reports, as required by Section 260570 concurrently or prior to submittals required by this section.**
- B. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

C. 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 NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final version to match installed conditions and additional loads.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
 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.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
 - 1. Panelboard Warranty Period: 18 months from date of Substantial Completion.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
 - 1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB (Electrification Products Division).
 - 2. Eaton.
 - 3. Schneider Electric USA (Square D).
 - 4. Siemens Industry, Inc., Energy Management Division
- B. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- 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. 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.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.
- G. Enclosures: **Flush and Surface**-mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, **Type 1**.
 - b. Outdoor Locations: NEMA 250, **Type 3R**.
 - c. **Kitchen / Wash-Down** Areas: NEMA 250, **Type 4X**.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, **Type 4**.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, **Type 12**.
 - 2. Height: 84 inches (2.13 m) maximum.
 - 3. 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: **Galvanized steel**.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
 - 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
- H. Incoming Mains:

1. Location: **Convertible between top and bottom.**
 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- I. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 4. Isolated Ground Bus (where indicated): Adequate for branch-circuit isolated ground conductors; insulated from box.
 5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- J. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
 6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- K. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
- L. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: 20 percent of poles unless indicated otherwise on drawings.
- M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

N. Provide factory installed integral SPDs in Panelboards as indicated on the drawings.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed, integrally mounted, plug-in-style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.

1. UL 1449 3rd Edition Type 2, 5kA nominal (L-N) rating.
2. Minimum Single-Impulse Current Ratings per Phase:
 - a. Line to Neutral: 80,000 A.
 - b. Line to Ground: 80,000 A.
 - c. Neutral to Ground: 40,000 A.
3. Protection modes shall be as follows:
 - a. Line to neutral.
 - b. Line to ground.
 - c. Neutral to ground.
4. EMI/RFI Noise Attenuation per UL 1283: -50 dB at 100 kHz.
5. Maximum UL 1449 Listed Voltage Protection Ratings (VPR's) shall not exceed the following:
 - a. 1200 V, line to neutral and line to ground on 277/480 V systems.
 - b. 700 V, line to neutral and line to ground on 120/208 V systems
 - c. 1800 V, line to line on 277/480 V systems.
 - d. 1200 V, line to line on 120/208 V systems.
6. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) shall not exceed the following:
 - a. 15%, allowable system voltage fluctuation on 277/480 V systems.
 - b. 25%, allowable system voltage fluctuation on 120/208 V systems.
 - c. 320 V, MCOV on 277/480 V systems.
 - d. 150 V, MCOV on 120/208 V systems.
7. Accessories for surge suppression:

- a. Audible alarm activated on failure of any surge diversion module.

2.3 DISTRIBUTION PANELBOARDS

- A. Panelboards: NEMA PB 1, distribution type.
- B. Mains: As indicated on plans.
- C. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Mains: As indicated on plans.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Provide Arc Energy Reducing Maintenance Switch on any breaker or fusible disconnect switch which can be adjusted 1,200 A or higher per NEC 240.87.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents. Circuit breaker types, frame sizes, and functionality shall be as required to meet the overcurrent device selectivity requirements as noted in 26 05 70 Coordination Study, but not less than as noted below:
 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. 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 shall be recorded with type, phase, and magnitude of fault that caused the 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 squared T response.
3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
5. Subfeed Circuit Breakers: Vertically mounted.
6. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Mechanical 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: Trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
 - i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - j. Multipole units enclosed in a single housing with a single handle.
 - k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - l. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.6 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder.
 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
- D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to [NECA 407] [NEMA PB 1.1].
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
 - 2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- F. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. 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.

- J. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- K. 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.
- L. Install filler plates in unused spaces.
- M. Stub four 1-inch (25 mm) empty conduits from flush panelboards into accessible ceiling space or space designated to be ceiling space in the future.
- N. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- O. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. 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. Do not 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 an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

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 electricity metering.
- B. Related Requirements
 - 1. Section 263100 - Photovoltaic and Battery Energy Storage System for integration to grid/off grid control system.

1.3 DEFINITIONS

- A. KY or KYZ Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity (kWh) that is based on a relay opening and closing in response to the rotation of the disk in the meter. Electronic meters generate pulses electronically.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of meter.
 - 2. For metering infrastructure components.
 - 3. For metering software.
- B. Shop Drawings: For electricity-metering equipment.
 - 1. Include elevation views of front panels of control and indicating devices and control stations.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Include series-combination rating data for modular meter centers with main disconnect device.

5. 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 used. Describe characteristics of network and other data communication lines.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Application and operating software documentation.
 2. Software licenses.
 3. Software service agreement.
 4. Device address list.
 5. Hard copies of manufacturer's operating specifications, user's guides for software and hardware, and PDF files on a USB storage device of hard-copy Submittal.
 6. Meter data sheet for each meter, listing nameplate data and serial number, accuracy certification, and test results.
 7. Meter installation and billing software startup report.

1.7 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 according to requirements indicated:
 1. Owner shall be notified and issued written permission no fewer than two days in advance of proposed interruption of electrical service.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of metering equipment that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Damage from transient voltage surges.

2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.9 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.
 - a. Comply with requirements of utility providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

B. Photovoltaic and Battery Energy Storage System

1. Coordinate with Photovoltaic and Battery Energy Storage System (microgrid) provider for meters required for operation of the microgrid. Coordinate exact communication protocol and required connections.

C. Building Management System

1. End use meters shall report to the building management system (BMS). Coordinate with Division 23 for connections to the BMS.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 916.
- C. System shall communicate with control system provided as part of the Photovoltaic and Battery Energy Storage System.

2.2 UTILITY METERING INFRASTRUCTURE

- A. Install metering accessories furnished by the utility company, complying with its requirements.
- B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.
 1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

- C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- D. Meter Sockets:
 - 1. Comply with requirements of electrical-power utility company.
 - 2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.
- E. Arc-Flash Warning Labels;
 - 1. Labels: Comply with requirements for "Arc-Flash Warning Labels" in Section 260573.19 "Arc-Flash Hazard Analysis." Apply a 3-1/2-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

2.3 ELECTRICITY METERS

- A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.
- B. Metering options built into electronic trip breakers, such as with Square D Micrologic, is acceptable given a gateway is provided to extract metering data from breakers and provide it to building management system.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Products Division.
 - 2. Eaton.
 - 3. E-Mon.
 - 4. GE Power; General Electric Company.
 - 5. Leviton Manufacturing Co., Inc.
 - 6. National Meter Industries.
 - 7. Sensus Metering Systems.
 - 8. Siemens Industry, Inc., Energy Management Division.
 - 9. Square D; Schneider Electric USA.
 - 10. eGuage Systems LLC.
- D. General Requirements for Meters:
 - 1. Enclosure: Supplied by meter manufacturer, NEMA 250, Type 1 minimum, with provisions for locking or sealing.
 - 2. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 3. Onboard Nonvolatile Data Storage: kWh, until reset.
 - 4. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: Split and solid core, complying with recommendation of meter manufacturer.

E. Functions and Accuracy:

1. Electric Meters shall report the following data 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. Kilowatts: Plus or minus 1 percent.
 - e. Kilovars: 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. Kilowatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.

F. kWh Meter: Electronic three-phase meters, measuring electricity use.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kWh and current kilowatt load. Retain accumulated kWh in a nonvolatile memory, until reset.

G. kWhd Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating the following:
 - a. Accumulative kWh.
 - b. Current time and date.
 - c. Current demand.
 - d. Historic peak demand.
 - e. Time and date of historic peak demand.
3. Retain accumulated kWh and historic peak demand in a nonvolatile memory, until reset.

H. Remote Reading Options:

1. Pulse Output: KY, complete with optical sensor and interface devices.
2. Serial Interface: RS-485, with Modbus RTU protocol.
3. TCP/IP adapter.

I. Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install arc-flash labels as required by NFPA 70.
- D. Wiring Method:
 - 1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
 - 3. Minimum conduit size shall be 1/2 inch (13 mm).

3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.
 - 2. Equipment Identification Labels: Self-adhesive labels with clear protective overlay.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Equipment and Software Setup:
 - a. Set meter date and time clock.
 - b. Test, calibrate, and connect pulse metering system.
 - c. Set and verify billing demand interval for demand meters.
 - d. Report settings and calibration results.
 - e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.
 - 2. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
 - 3. Turn off circuits supplied by metered feeder and secure them in off condition.

4. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
 5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
 6. Generate test report and billing for each tenant or activity from the meter reading tests.
- C. Electricity metering will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Train Owner's clerical and maintenance personnel to use, adjust, operate, and maintain the electronic metering and billing software.

END OF SECTION 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Straight blade receptacles.
 - 2. GFCI receptacles.
 - 3. Marked controlled Receptacles.
 - 4. Twist-locking receptacles.
 - 5. Pendant cord-connector devices.
 - 6. Cord and plug sets.
 - 7. Snap switches.
 - 8. Wall plates.
 - 9. Poke-thru Assemblies.
 - 10. Cord reels
 - 11. Push-button stations and buzzers
 - 12. Pilot lights

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Arrow-Hart Devices; Eaton (Eaton), formerly Cooper Wiring Devices.
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.
- E. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- F. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: Gray unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Standby Electrical System: Red.
- G. Wall Plate Color: For plastic covers, match device color.
- H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.3 STRAIGHT BLADE RECEPTACELS

A. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
5. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5361-T (single), 5352-T (duplex).
 - b. Hubbell; HBL5361TR (single), 5362TR (duplex).
 - c. Leviton; 5361-T (single), 5362-T (duplex).
 - d. Pass & Seymour; TR5361 (single), TR5362 (duplex).

2.4 GFCI RECEPTACLES

A. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A:

1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Type: Feed through.
4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

- B. GFCI receptacles may be arranged to protect downstream receptacles if and only if the downstream receptacle is in the same room as the GFCI receptacle. Provide machine printed labels on such downstream receptacles indicating the receptacle is "GFCI PROTECTED".

2.5 MARKED CONTROLLED RECEPTACLES

A. Plugload Controlled Receptacles, 125 V, 20 A:

1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Permanently marked with "CONTROLLED" per N.E.C.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with NEMA WD 1, UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Controlled Receptacle Marking" Article. Permanently marked with "CONTROLLED" per N.E.C.
5. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; 5262-1 (lower switched), 5262-2 (full receptacle switched).
 - b. Cooper; equal.

- c. Hubbell; equal.
- d. Pass & Seymour; equal.

2.6 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 120 V, 20 A:

- 1. Configuration: NEMA WD 6, Configuration L5-20R
- 2. Standards: Comply with UL 498.
- 3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; CWL520R.
 - b. Hubbell; HBL2310.
 - c. Leviton; 2310.
 - d. Pass & Seymour; L520-R.

2.7 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.
- B. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.
- C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
- E. Standards: Comply with FS W-C-596.

2.8 CORD AND PLUG SETS

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.9 TOGGLE SWITCHES, 120/277 V, 20 A

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; CSB120 (single pole), CSB220 (two pole), CSB320 (three way), CSB420 (four way).
 - b. Hubbell; CSB120 (single pole), CSB220 (two pole), CSB320 (three way), CSB420 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; CSB20AC1 (single pole), CSB20AC2 (two pole), CSB20AC3 (three way), CSB20AC4 (four way).
- C. Pilot Light Switches, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; AH1221PL for 120 V and 277 V.
 - b. Hubbell; HBL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PR for 277 V.
 - d. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277V.
 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; AH1221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2KL.
 - d. Pass & Seymour; PS20AC1-L.
 2. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.
 - b. Hubbell; HBL1557.
 - c. Leviton; 1257.
 - d. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995L.

- b. Hubbell; HBL1557L.
- c. Leviton; 1257L.
- d. Pass & Seymour; 1251L.

2.10 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material: 0.035-inch- (1-mm-) thick, satin-finished type 302 stainless steel.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.
 - 1. Vertical Mount: Hubbell WP26M, Pass & Seymour WIUCAST1 or approved equal.
 - 2. Horizontal Mount: Hubbell WP8MH, Pass & Seymour WIUCAST1 or approved equal.

2.11 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 - 3. Square D/Schneider Electric.
 - 4. Thomas & Betts Corporation.
 - 5. Wiremold Company (The).
- B. Flush Type: One-piece, flush factory-fabricated and -prewired assembly of below-floor junction box unit with multichanneled, through-floor raceway/firestop unit and detachable mating floor service outlet assembly as specified above. Features include the following:
 - 1. Size: Selected to fit nominal 3-inch (75-mm) cored holes in the floor and matched to the floor thickness.
 - 2. Fire Rating: Unit is listed and labeled to match the fire rating of the floor.
 - 3. Receptacle: 5-20R duplex receptacle with spring loaded cover.
 - 4. Two, 1/2-inch openings for future data cable.
 - 5. Brass carpet flange and matching brass duplex flap covers.
 - 6. Hubbell Catalog No. PT7FSDBRS2, or approved equal.
- C. Pedestal Type: Two-piece, flush factory-fabricated and prewired assembly of below-floor junction box unit with multichanneled, through-floor raceway/firestop unit and detachable mating floor service outlet assembly, as specified above. Features include the following:
 - 1. Size: Selected to fix nominal 3-inch (75-mm) cored holes in the floor and matched to the floor thickness.

2. Fire Rating: Unit is listed and labeled to match the fire rating of the floor.
3. Power Conduit: ¾-inch EMT.
4. Low-Voltage Conduit: 1-1/4" EMT.
5. Through-Floor Fitting: Hubbell PT7XC, or approved equal.
6. Pedestal Housing: Hubbell FR80A, or approved equal.
7. Provide faceplates, devices, connections to systems furniture, etc., as indicated on drawings for a complete system. Low-voltage cabling extending from poke-through assemblies to systems furniture shall be contained in flexible metallic raceway.
8. Color: Satin aluminum housing and plates.

2.12 CORD REELS

- A. Commercial grade cord reel as manufactured by Hubbell or approved equal with #12 AWG SJO cable, box with strain relief and two duplex receptacles mounted back-to-back in a black portable outlet box. Reel housing shall be white. Reel shall be equipped with 5-foot power supply cord and 20amp straight blade plug. Length of cable shall allow box to be extended down to 36-inches AFF. Provide with mounting base and ball stop.
 1. Product: Subject to compliance with requirements, provide the following or approved equal:
 - a. Hubbell; HBLI25123R220M1.
- B. Receptacle shall be as defined elsewhere in this section.

2.13 PUSH-BUTTON STATIONS AND BUZZERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Edwards Signaling, or approved equal.
- B. Push-button Station: Weather-proof, one-piece, flush factory-fabricated and prewired assembly. Features include the following:
 1. Weatherproof diaphragm enclosing the mechanism, with rubber gasket at wall plate.
 2. Flush mount, satin chrome finish.
 3. Contact Rating: 120-volt.
 4. Edwards 852, or approved equal.
- C. Buzzer: Heavy-duty, one-piece, surface mount plug-in assembly. Features include the following:
 1. Corrosion-resistant epoxy finish.
 2. Mounting plate plug-in assembly for standard single-gang box.
 3. Device Rating: 120-volt.
 4. Adjustable volume control.
 5. Edwards 340A-N5, or approved equal.

2.14 PILOT LIGHTS

- A. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Pass & Seymour; 2151-RED for 120-volt applications
 - 2. Approved equal.
- B. Description: Neon bulb emits light through transparent lens, illuminated when 120-volt power is "ON". Provide engraved wall plate indicating load served.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
- D. Device Installation:
 - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Use tamper-proof receptacles for all duplex receptacles on the project.

G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 114 to 126 V.
2. Percent Voltage Drop under 15-A Load: A value over 5 percent is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar

problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Cartridge fuses rated 600 V and less for use in switches, switchboards, and controllers.

1.3 SUBMITTALS

- A. Product Data: Include the following for each fuse type indicated:
 - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
- B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses from a single manufacturer.
- 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 NEMA FU 1.
- D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Quantity equal to one percent of each fuse type and size, but no fewer than three of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussman, Inc.
 - 2. Littelfuse, Inc.
 - 3. Mersen (formerly Ferraz Shawmut, Inc.)

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Service Entrance: Class L time delay or Class J time delay.

- B. Feeders: Class L time delay or Class J time delay.
- C. Motor Branch Circuits: Class J time delay.
- D. Other Branch Circuits: Class J time delay

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 262813

SECTION 263100.22 – PHOTOVOLTAIC AND BATTERY ENERGY STORAGE SYSTEM SIZE
AND SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Plans and general provisions of the Contract, including General Conditions and Supplemental General Conditions and other Division 01 Specification Sections, apply to this Section.
- B. 263100 - Photovoltaic and Battery Energy Storage System, for general requirements related to the photovoltaic and battery energy storage system.

1.2 SUMMARY

- A. Section Includes:
 - 1. Specific system size design intent for Henderson.
 - 2. Sequence of Operations for Henderson.

1.3 HENDERSON – SYSTEM DESCRIPTION

- A. Design intent: The PV+BESS system sizing included in the bridging documents are sized to provide the following intent:
 - 1. Provide continuous energy for the whole site for one day of autonomy. Based on a daily average energy demand of 1224kWh, depth of discharge of 80%, and cold temperature factor of 0.95.
 - 2. System shall be Zero Net Energy ready. System is sized to allow for enough PV to offset 100% of annual electrical energy use.
- B. The Photovoltaic and storage system shall be composed of the following electrical equipment:
 - 1. Minimum 612kW DC of photovoltaic modules. The modules are to be located in the dedicated area on the plans on top the roof and shade canopies.
 - 2. Minimum 612kW AC of photovoltaic inverters.
 - 3. Maximum DC:AC ratio of 1.0.
 - 4. 1250/2500kWh battery storage systems with integral inverter, HVAC, and controls. Battery storage system inverters shall be capable of a minimum, continuous, combined output of 1250kW.
 - 5. Battery Isolation transformer (if required)
 - 6. Motor operated circuit breakers (provided as part of main switchboard construction as specified in section 262413)
 - 7. Electricity meters (as specified in 262713) to feed metering data to control system.

8. Control system to balance load and provide required functionality as described in the sequence of operations.
- C. Battery system, PV inverters and controls shall be part of, and be commissioned as, a turnkey system.
- D. Interconnection - The BESS shall interconnect to main switchboard MDB ahead of the main breaker. The PV system can interconnect to MDB as currently shown in plans, or via BESS switchboard if routing and disconnect locations are more feasible. The BESS switchboard ampacity and associated feeder and fuse should be adjusted as necessary if this interconnection is selected. A fused switch for each system will allow for disconnection of the PV and/or BESS from the rest of the power distribution system and shall act as the utility disconnects if required by WAPA. The utility service circuit breaker and building breaker in MDB will be motor operated to allow for load shed and grid disconnection via the control system.
1. A production meter, separate from the control system meter, shall be provided if required by the utility.
- E. Sequence of Operation:
 1. Normal Operation: BESS will operate in “grid following” mode and charge/trickle charge to maintain capacity. PV will act as a typical grid connected system, feeding the distribution system when system is active.
 2. Battery Charging (grid connection): Significant battery charging beyond trickle charging shall be coordinated with WAPA to ensure low grid impact. Ideally it should occur outside of heavy grid use hours, such as between 12AM and 6AM. Coordinate with WAPA for ideal charging hours. Reduced charging rates during the day can be considered, if offered.
 3. Battery Charging (off-grid): Battery charging will occur when electrical load requirements are being met and there is excess PV production to charge the BESS.
 4. Non-Event outage (automatic) - Upon sensing loss of utility power, the motor operated main circuit breaker will open up to isolate the system from the grid. The BESS will switch from “grid following” to “grid forming” (duration around 100ms). During this time, the PV system will drop offline. The BESS will start feeding loads to building D and F. After 5 minutes of seeing the new microsystem grid (powered from the BESS) the PV inverters will reconnect and start feeding loads as well. Should the PV system be capable of producing more energy than the load demand, the control system shall begin charging the BESS. If the PV system is capable of producing more energy than the load demand and the BESS charging demand, the control system shall curtail the PV production to match the load demand plus battery charging demand. Should the batteries discharge to the point where they only have 600kWh of remaining capacity, the building F (non-shelter) motor-operated circuit breaker shall open to shed the non-shelter buildings to ensure there is 24 hours minimum back up power for the gym (shelter).
 5. Storm Event outage (semi-automatic): Sequence 4 shall be followed unless the “Shelter Mode” button is closed. With either event, the building motor operated circuit breaker will open to shed the non-shelter loads. This may happen under grid power (button actuation) or off-grid (automatic when 600kWh capacity reached).

This will shed the non-critical loads so the PV and BESS will only feed the shelter loads.

6. Restoration of utility power: Upon restoration of utility power, the motor operated utility service circuit breaker for MDB will close. At this point the BESS will return to “grid following” and charge per sequence 2. If the non-shelter breaker is open, it shall close shortly after the main circuit breaker has closed to limit inrush on the battery system. The PV inverters will act as UL1741 devices, dropping offline during the power switch and reconnecting to the grid after 5 minutes of stable utility power.

7. Installation

- a. The PV installation shall be within the bounds shown on the plans. Any complications or issues with final PV design and proposed design shall be brought to the attention of the Architect.

END OF SECTION 263100.11

SECTION 263323.11 - CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes the following central battery and power conversion equipment rated 600 V and less for emergency lighting:
 - 1. Uninterruptible (UPS-type) central battery equipment. (Interruptible type central battery equipment is subject to approval by design team),

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. IBC: International Building Code.
- C. Interruptible: As used in the Section Text, an off-line, passive-standby or line-interactive, inverter-only unit, with an intentional interruption of power to the load until an internal transfer switch picks up and transfers the load to the unit's inverter and internal battery source on loss of the "normal" source, and then retransfers to the "normal" source when it is restored. Transfer time can be "slow" (up to approximately 1 second) or "fast" (2-4 ms or 40-50 ms, depending on manufacturer).
- D. LED: Light-emitting diode.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. OCPD: Overcurrent protective device.
- G. PC: Personal computer.
- H. PWM: Pulse-width modulated.
- I. TDD: Total demand (harmonic current) distortion (also listed as "THD" in catalog data by manufacturers).
- J. THD(V): Total harmonic voltage demand.

- K. Uninterruptible: As used in the Section Text, an on-line, double-conversion (rectifier/inverter) unit, with no interruption of power to the load on interruption and restoration of the "normal" source.
- L. UPS: Uninterruptible power supply.
- M. VRLA: Valve-regulated lead acid.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and rating of central battery equipment unit.
 - 1. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, shipping splits, and furnished options, specialties, and accessories.
- B. Shop Drawings: For each type and rating of central battery equipment unit.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
 - 3. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
 - 4. Include elevation, details, and legends of control and indication displays.
 - 5. Include -circuit current (withstand) rating of unit.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Seismic Qualification Data: For central battery equipment, accessories, and components, from manufacturer.
 - 1. Certificate of compliance.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Product Certificates: For each type of central battery equipment.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For central battery equipment to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing central battery equipment.
 - b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - c. Manufacturer's written instructions for selecting and setting field-adjustable controls and status and alarm points

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment in fully enclosed vehicles.
- B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
 - 2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
 - 3. Humidity: More than 95 percent (condensing).
 - 4. Altitude: Exceeding 3300 feet (1000 m).
- B. Interruption of Existing Electrical Distribution Systems: Do not interrupt electrical distribution systems within 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 Owner no fewer than two days in advance of proposed interruption of electrical systems.
 - 2. Comply with NFPA 70E.

1.10 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.11 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
 - 1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
 - a. Central Battery Equipment (excluding Batteries): One year(s).
 - b. Standard VRLA Batteries:
 - 1) Full Warranty: One year(s).
 - 2) Pro Rata: Nine years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Central battery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated central battery equipment shall be tested and certified by an NRTL as meeting ICC-ES AC 156 test procedure requirements.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 UNINTERRUPTIBLE (UPS-TYPE) CENTRAL BATTERY EQUIPMENT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Products Division.
 - 2. Chloride; Signify North America Corp.
 - 3. Cooper Industries, Inc.
 - 4. Crucial Power Products.
 - 5. Dual-Lite.
 - 6. Emergi-Lite; a Thomas & Betts brand.
 - 7. Lithonia Lighting; Acuity Brands Lighting, Inc.
 - 8. Myers Power Products, Inc.
 - 9. Signify North America Corporation (formerly Philips Lighting).

B. General Requirements for Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

C. Performance Requirements for UPS-Type Central Battery Equipment:

1. Type: On-line, double conversion.
2. Continuously provide uninterrupted ac power to connected emergency electrical lighting system.
3. Automatic Operation:
 - a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier and inverter, with battery connected in parallel with rectifier output.
 - b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
 - c. If normal power fails, battery continues to supply regulated ac power through the inverter to the load without switching or disturbance.
 - d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier then supplies power to the load through the inverter and simultaneously recharges battery.
 - e. If battery becomes discharged and normal supply is available, rectifier charges battery. When battery is fully charged, rectifier automatically shifts to float-charge mode.
 - f. If any element in the rectifier/inverter string fails and power is available at normal supply terminals of system, static transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
 - g. If a fault occurs in system supplied by the inverter output, and current flows in excess of the overload rating of the inverter, static transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
 - h. When fault has cleared, static transfer switch returns the load to inverter output.
 - i. If battery is disconnected, inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.
4. Manual Operation:
 - a. Turning inverter off causes static transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
 - b. Turning inverter on causes static transfer switch to transfer the load to inverter.

D. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
 2. Input Frequency Tolerance: Plus or minus 3 percent of central battery equipment frequency rating.
 3. Synchronizing Slew Rate: 1 Hz per second, maximum.
 4. Minimum Off-Line Efficiency: 95 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or operating condition.
 6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
 7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F (70 deg C).
 8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
 9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C).
 10. Humidity Rating: Less than 95 percent (noncondensing).
 11. Altitude Rating: Not exceeding 3300 feet (1005 m).
 12. Off-Line Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
- E. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.
- F. Controls and Indication:
1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:
 - a. Normal power available.
 - b. Status of system.
 - c. Battery charging status.
 - d. On battery power.
 - e. System fault.
 - f. External fault.
 2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
 - a. Keypad: In addition to required programming and control keys, include the following:
 - 1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
 - 2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
 - 3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

- b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:
- 1) Real-time clock with current time and date.
 - 2) Tests and Events Logs: Record and store up to 25 tests and events:
 - a) Dates.
 - b) Times.
 - c) Durations.
 - d) Output voltage and currents.
 - 3) Alarm Logs: Record and store up to 25 alarms:
 - a) Dates.
 - b) Times.
 - c) Alarm type.
 - 4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:
 - a) Input and output voltage (V ac) and output current (A ac).
 - b) Battery voltage (V dc) and current (A ac).
 - c) Fault or alarming status (code).
 - d) Power output (VA).
 - e) Inverter load (W).
 - f) Ambient temperature (deg F).
 - g) System run time (cumulative days).
 - h) Inverter run time (cumulative minutes).
 - 5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:
 - a) High/low battery charge voltage.
 - b) High/low input voltage.
 - c) Battery nearing low-voltage condition.
 - d) Battery low voltage.
 - e) High ambient temperature.
 - f) Inverter fault.
 - g) Output fault.
 - h) Output overload.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

H. Rectifier:

1. Description: Solid state, with the following operational features:
 - a. Automatically convert incoming ac voltage to regulated dc bus voltage, with less than 2 percent rms ripple voltage with inverter fully loaded and batteries disconnected.
 - b. Rectified Efficiency: Not less than 97 percent.
 - c. Generator compatible.

I. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:
 - a. Automatically regulate output voltage to within plus or minus 3 percent, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes, with recovery within 3 cycles.
 - b. Automatically regulate output frequency to within plus or minus 0.05 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
 - c. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
 - d. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
 - e. Load Power Factor: 0.5 lead to 0.5 lag.

J. Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

K. Batteries:

1. Description: Standard VRLA batteries.
 - a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.
2. Battery Disconnect and OCPD: Manufacturer's standard.

L. Line Conditioning and Filtering:

M. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities.
- N. Integral Output Disconnecting Means and OCPD:
 1. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.
 - a. Normally Closed: Quantity As Required.

2.3 ENCLOSURES

- A. Central Battery Equipment Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 1. Dry and Clean Indoor Locations: Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
 2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

2.4 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect central battery equipment according to UL 924.
- B. Factory Tests: Test and inspect assembled central battery equipment according to UL 924. Affix standards organization's label. Include the following:
 1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 2. Full-load test.
 3. Transient-load response test.
 4. Overload test.
 5. Power failure test.
- C. Central battery equipment 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. Receive, inspect, handle, and store central battery equipment according to NECA 411.

- B. Examine areas, surfaces, and substrates to receive central battery equipment, with Installer present, for compliance with requirements for installation tolerances, structural support, ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.
- C. Examine equipment before installation. Reject equipment that is wet, moisture damaged, or mold damaged.
- D. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of central battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install central battery equipment and accessories according to NECA 411.
- C. Wall-Mounted Central Battery Equipment: Install central battery equipment on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For units not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- D. Floor-Mounted Central Battery Equipment: Install central battery equipment on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

- G. Comply with NECA 1.
- H. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used for low-voltage control and alarm wiring. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - 3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- J. 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 CONNECTIONS

- A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label central battery equipment with engraved nameplates.
 - 3. Label each separate cabinet, for multi-cabinet units.
 - 4. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for central battery equipment, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of central battery equipment units.

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. Acceptance Testing Preparation:
 - 1. Inspect and Test Each Component:
 - a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
 - b. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
 - c. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
 - 2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
 - 3. Test continuity of each circuit.
 - 4. Verify that input voltages and frequencies at central battery equipment locations are within voltage and frequency limits specified in Part 2. If outside this range, notify Owner before closing input OCPDs.
 - 5. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.
 - 6. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of central battery equipment. Remove front panels so joints and connections are accessible to portable scanner.
 - 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Central battery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, and other adjustable parts.
- C. Set the automatic system test parameters.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace central battery equipment whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 263323.11

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes nonautomatic transfer switches rated 600 V and less, including the following:
 - 1. Remote annunciator system.
 - 2. Remote annunciator and control system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
 - 2. Include material lists for each switch specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer-authorized service representative or 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. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Features and operating sequences, both automatic and manual.
 - b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: 12 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 110.
- D. Comply with UL 1008 unless requirements of these Specifications are stricter.
- E. 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 3 cycles.

- F. 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.
- G. 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.
- H. 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.
- I. 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 mechanically actuated.
- J. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- K. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- L. 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.
- M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - 4. Accessible via rear or front access.
- N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 NONAUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Russelectric, Inc.
 2. Asco Power Technologies
 3. Caterpillar, Inc.
 4. Cummins Power Generation
 5. Eaton
- B. Manual and Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
- C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- D. Pilot Lights: Indicate source to which load is connected.
- E. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternative-source sensing circuits.
1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 2. Emergency Power Supervision: Red light with nameplate engraved "Alternative Source Available."
- F. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- G. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
 2. Contacts: Silver composition or silver alloy for load-current switching.
 3. Conductor Connectors: Suitable for use with conductor material and sizes.
 4. Material: Hard-drawn copper, 98 percent conductivity.
 5. Main and Neutral Lugs: Mechanical type.
 6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 7. Connectors shall be marked for conductor size and type according to UL 1008.

2.3 TRANSFER SWITCH ACCESSORIES

A. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:
 - a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Switch position.
 - c. Switch in test mode.
 - d. Failure of communication link.
4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
 - a. Indicating Lights: Grouped for each transfer switch monitored.
 - b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
 - c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
 - d. Lamp Test: Push-to-test or lamp-test switch on front panel.

B. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Include the following functions for indicated transfer switches:
 - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Indication of switch position.
 - c. Indication of switch in test mode.
 - d. Indication of failure of digital communication link.
 - e. Key-switch or user-code access to control functions of panel.
 - f. Control of switch-test initiation.
 - g. Control of switch operation in either direction.
 - h. Control of time-delay bypass for transfer to normal source.
3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - a. Controls and indicating lights grouped together for each transfer switch.
 - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.

- c. Digital Communication Capability: Matched to that of transfer switches supervised.
- d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

2.4 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 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 and boxes specified in Section 260533 "Raceways and Boxes 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. 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. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify that the unit is clean.
 - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - f. Verify that manual transfer warnings are attached and visible.
 - g. Verify tightness of all control connections.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
 - i. Perform manual transfer operation.
 - j. Verify positive mechanical interlocking between normal and alternate sources.
 - k. Perform visual and mechanical inspection of surge arresters.
 - l. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
 - a. Perform insulation-resistance tests on all control wiring with respect to ground.
 - b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
 - c. Verify settings and operation of control devices.
 - d. Calibrate and set all relays and timers.
 - e. Verify phase rotation, phasing, and synchronized operation.
 - f. Perform automatic transfer tests.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay on transfer.
 - 4) Alternative source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.

- 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer on normal power restoration.
 - 8) Engine cool-down and shutdown feature.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. 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.

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. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

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 lightning protection system for ordinary structures. System shall be designed with consideration to aesthetics of all system parts at or above the roof.

1.3 DEFINITIONS

- A. LPI: Lightning Protection Institute
- B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

- A. Product Data: For each type of 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. Calculations required by NFPA 780 for bonding of metal bodies.
- C. Qualification Data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL.
- D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the roofing material.
- E. Field quality-control reports.

1.5 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

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL.
- B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.7 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ERICO International Corporation.
 - 2. Harger Lightning Protection, Inc.
 - 3. Heary Bros. Lightning Protection Co. Inc.
 - 4. Independent Protection Co.
 - 5. Robbins Lightning Inc.
 - 6. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

- A. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- B. 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. Aluminum unless otherwise indicated.
 - 2. Bases shall be compatible with roofing membrane and approved by the roof system manufacturer.
- B. Class 1 Main Conductors:
 - 1. Stranded Copper: 57,400 circular mils in diameter.
 - 2. Aluminum: 98,600 circular mils in diameter.
- C. Secondary Conductors:
 - 1. Stranded Copper: 26,240 circular mils in diameter.
 - 2. Aluminum: 41,400 circular mils in diameter.
- D. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.
- E. 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 and NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Conceal to the maximum extent possible the following conductors:
 - 1. Horizontal conductors between air terminals.
 - 2. Down conductors, utilizing HSS structural columns. Coordinate handholes with structure provider.
 - 3. Interior conductors.
 - 4. Conductors within normal view from exterior locations at grade within 200 feet of building.

- 5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- D. For penetrations through roof for down conductors, utilize a waterproof thru-roof, thru-rod cable connector assembly to cleanly penetrate the roof at an air terminal. Do not utilize roof boots in locations within normal view from exterior locations at grade within 200 feet of building. Coordinate location and waterproofing of all penetrations with roof supplier.
- E. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above membrane roofing.
- F. Air Terminals on Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- G. 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: bolted connectors and crimp.
- 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. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

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SCHEMATIC DESIGN

END OF SECTION 264113

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes the following types of LED luminaires:
 - 1. Cylinder.
 - 2. Downlight.
 - 3. Recessed, linear.
 - 4. Strip light.
 - 5. Surface mount, linear.
 - 6. Surface mount, nonlinear.
 - 7. Suspended, linear.
 - 8. Suspended, nonlinear.
- B. Related Requirements:
 - 1. Section 260943 "Network Lighting Controls" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
 - 2. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire 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.

C. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

D. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 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. Luminaires.
2. Suspended ceiling components.

3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:
 - a. Other luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Ceiling-mounted projectors.
7. Moldings.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

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

C. Product Certificates: For each type of luminaire.

D. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.

E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
 - 1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."
- C. Ambient Temperature: 41 to 104 deg F.
 - 1. Relative Humidity: Zero to 95 percent.
- D. Altitude: Sea level to 1000 feet.

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI.
- C. Recessed luminaires shall comply with NEMA LE 4.
- D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- F. California Title 24 compliant.

2.3 MATERIALS

- A. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- B. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for sheet steel.
- C. Stainless Steel:
 - 1. 1. Manufacturer's standard grade.
 - 2. 2. Manufacturer's standard type, ASTM A240/240M.
- D. Galvanized Steel: ASTM A653/A653M.
- E. Aluminum: ASTM B209.

2.4 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gauge.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and re-lamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:
 - a. Pendant mount with 5/32-inch- diameter aircraft cable supports 10 feet in length.
 - b. Hook mount.
2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.
- D. When requested within 12 months of date of Substantial Completion, provide on-site assistance in replacing or repairing all defective luminaires. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 265119

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Exit signs.
 - 2. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of exit sign and emergency lighting support.
 - 1. Include data on features, accessories, and finishes.
 - 2. Include physical description of the unit and dimensions.
 - 3. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
 - 4. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
 - a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency.
 - b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

- B. Shop Drawings: For nonstandard or custom luminaires.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Product Schedule:
 - 1. For emergency lighting units. Use same designations indicated on Drawings.
 - 2. For exit signs. Use same designations indicated on Drawings.

1.5 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. Luminaires.
 - 2. Suspended ceiling components.
 - 3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
 - 4. Structural members to which equipment will be attached.
 - 5. Size and location of initial access modules for acoustical tile.
 - 6. Items penetrating finished ceiling including the following:
 - a. Other luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Ceiling-mounted projectors.
 - e. Sprinklers.
 - f. Access panels.
 - 7. Moldings.
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.
- C. Product Certificates: For each type of luminaire.
- D. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Provide seismic qualification certificate for each piece of equipment.

- E. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.

2.3 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Operating at nominal voltage of 120 V ac, or 277 V ac.
 2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.

2.4 MATERIALS

- A. Metal Parts:
 1. Free of burrs and sharp corners and edges.
 2. Sheet metal components shall be steel unless otherwise indicated.
 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access:
 1. Smooth operating, free of light leakage under operating conditions.
 2. Designed to permit relamping without use of tools.
 3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Housings:
 1. Extruded aluminum housing.
 2. Powder coat finish.

2.5 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. 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.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gauge.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 3. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. 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.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

- B. Luminaire will be considered defective if it does not pass operation tests and inspections.

- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, signs, or luminaires that are defective.

- a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265213

SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Poles and accessories for support of luminaires.

1.3 DEFINITIONS

- A. EPA: Equivalent projected area.
- B. Luminaire: Complete luminaire.
- C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.
- D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

- A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.
 - 1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
 - 2. Include finishes for lighting poles and luminaire-supporting devices.
 - 3. Anchor bolts.
 - 4. Manufactured pole foundations.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.

4. Anchor bolt templates keyed to specific poles and certified by manufacturer.
 5. Method and procedure of pole installation. Include manufacturer's written installations.
- C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.
- B. Seismic Qualification Data: For 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. Material Test Reports:
1. For each foundation component, by a qualified testing agency.
 2. For each pole, by a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: Manufacturer's standard warranty.
- G. Soil test reports

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Pole repair materials.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- B. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.
- B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event.
 - 2. Component Importance Factor: 1.5.
- C. Structural Characteristics: Comply with AASHTO LTS-6-M.
- D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.
- E. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.

- F. Ice Load: Load of 3 lbf/sq. ft., applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.
- G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.
 - 1. Basic wind speed for calculating wind load for poles 50 feet high or less is 182 mph.
 - a. Wind Importance Factor: 1.00.
 - b. Minimum Design Life: 25 years.
 - c. Velocity Conversion Factor: 1.00
 - d. Risk Category: IV.
 - e. Exposure: D (per U.S. Virgin Island special wind region)
- H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.
- I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

- A. Source Limitations: Obtain poles from single manufacturer or producer.
- B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.
- C. Poles: Comply with ASTM A240/A240M, stainless steel with a minimum yield of 55,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.
 - 1. Shape: Round, straight.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- D. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.
- E. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adaptor, then bolted together with stainless steel bolts.
 - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.
- F. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

- G. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
 - 1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
- H. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.
- I. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- J. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.
- K. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.
- L. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.
- M. Finish and construction shall be constructed for the exterior environment. Fixture shall be constructed of marine grade materials (aluminum, stainless steel) or finished with a polyester powder coat finish that passes the following tests:
 - 1. ASTM B117 Corrosion test
 - 2. ASTM D522 Cracking and loss of adhesion
 - 3. AAMA 2604 salt spray test.

2.3 MOUNTING HARDWARE

- A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi.
 - 1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
 - 2. Threading: Uniform National 8, Class 2A.
- B. Nuts: ASTM A563, Grade A, Heavy-Hex.
 - 1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
- C. Washers: ASTM F436, Type 1.
 - 1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.

2.4 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- C. Examine roughing-in for foundation and conduit to verify actual locations of installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POLE FOUNDATION

- A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Anchor Bolts: Install plumb using manufacturer-supplied template, uniformly spaced.

3.3 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.
 - 1. Fire Hydrants and Water Piping: 60 inches.
 - 2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet.

- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.
- F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

- A. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

- A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

END OF SECTION 265613

SECTION 265619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
 - 3. Luminaire-mounted photoelectric relays.

- B. Related Requirements:

- 1. Section 260923 "Lighting Controls" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
 - 2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.
 - 1. Arrange in order of luminaire designation.

2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with **IES Lighting Measurements Testing and Calculation Guides, of each luminaire type.**
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire 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.

C. Product Schedule: For luminaires and lamps. **Use same designations indicated on Drawings.**

D. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports **and seismic restraints.**

1.5 INFORMATIONAL SUBMITTALS

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

1. Luminaires.
2. Structural members to which luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.
9. Paint finish certifications.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

- C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of the following:
 - 1. Luminaire.
 - 2. Photoelectric relay.
- E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
 - 2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.9 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
 - 1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. UL Compliance: Comply with UL 1598 and listed for wet location.

- E. CCT of 3000 K unless noted otherwise on the Light Fixture Schedule.
- F. L70 lamp life of 50,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- H. Internal driver.
- I. Nominal Operating Voltage: 277V or 420V.
- J. Lamp Rating: Lamp marked for **outdoor use** and corrosive environments.
- K. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- L. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

- A. Area and Site:
 - a. Refer to luminaire schedule on drawings for exact requirements.

2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Marine-grade aluminum alloy. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- E. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- F. Housings:
 - 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.

2. Provide filter/breather for enclosed luminaires.
- G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.5 FINISHES

- A. Finish and construction shall be constructed for the exterior environment. Fixture shall be constructed of marine grade materials (aluminum, stainless steel) or finished with a polyester powder coat finish that passes the following tests:
1. ASTM B117 Corrosion test
 2. ASTM D522 Cracking and loss of adhesion
 3. AAMA 2604 salt spray test.
- B. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- C. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- D. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
- E. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" 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.
 - a. Color: As selected from manufacturer's standard catalog of colors.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, canopy ceilings, and overhang ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls Attached to a minimum **1/8 inch** backing plate attached to wall structural members

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

I. Coordinate layout and installation of luminaires with other construction.

J. 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.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Where outside the sidewalk or pathways, install on concrete base with top **4 inches** above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

C. Where inside a sidewalk or pathway, install on concrete base with top flush with finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Match concrete base top finish with adjacent concrete. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with **0.010-inch-** thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Communications equipment coordination and installation.
 - 2. Sleeves for pathways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common communications installation requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of communications 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. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

- 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:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 2. Sealing Elements: NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
 3. Pressure Plates: Stainless steel. Include two for each sealing element.
 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

- A. Comply with NECA 1.

- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. 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.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using hot dip galvanized steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use 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.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

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. BCT: Bonding conductor for telecommunications.
- B. EMT: Electrical metallic tubing.
- C. TGB: Telecommunications grounding busbar.
- D. TMGB: Telecommunications main grounding busbar.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. Ground rods.
 - 2. Ground and roof rings.
 - 3. BCT, TMGB, TGBs, and routing of their bonding conductors.
- B. Qualification Data: For Installer, installation supervisor, and field inspector.

- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Result of the ground-resistance test, measured at the point of BCT connection.
 - b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode..

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 Installer 2, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently registered by BICSI as a registered communications distribution designer to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

- A. Comply with J-STD-607-C.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with all additional requirements of Divisions 27 and 28, conform to requirements of Division 26.
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Cable Tray Equipment Grounding Wire: No. 6 AWG, minimum.
- D. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a

flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

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: 28 kmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

- A. 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.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Burndy; Part of Hubbell Electrical Systems.
 2. Chatsworth Products, Inc.
 3. ERICO
 4. Harger Lightning and Grounding.
 5. Panduit Corp.
 6. Tyco Electronics Corp.
- 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-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.
- F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.
 3. Panduit Corp.

- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with J-STD-607-C.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide a 4-inch (100-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-C.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
 - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-C. Predrilling shall be with holes for use with lugs specified in this Section.
 - 1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 - 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 - 3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm long, with) stainless-steel or copper-plated hardware for attachment to the rack.

2.5 LABELING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brother International Corporation.
 - 2. HellermannTyton.
 - 3. Panduit Corp..
- B. Comply with TIA/EIA-606-A 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 (10 mm). 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 BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with J-STD-607-C.

3.3 APPLICATION

- A. Conductors: Install stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- B. 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.
- C. Conductor Support:
 - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm.)
- D. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch (900-mm) intervals.

4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.
- B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.5 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 TMGB with insulated bonding conductor.
- E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.
- H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

- I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.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.

3.6 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 - 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
 - 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.7 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 TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 - 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.
- D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 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. Surface pathways.
7. Boxes, enclosures, and cabinets.
8. Handholes and boxes for exterior underground cabling.

- B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

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: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. 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."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways and surface pathways and for each color and texture specified, 12 inches (300 mm) long.

1.5 INFORMATIONAL SUBMITTALS

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

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

B. Qualification Data: For professional engineer.

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

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

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. Alpha Wire Company.
 4. Anamet Electrical, Inc.
 5. Electri-Flex Company.
 6. O-Z/Gedney; a brand of EGS Electrical Group.
 7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.
 8. Republic Conduit.
 9. Robroy Industries.
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company; a division of John Maneely 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. 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 and IMC.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- 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: Setscrew or compression.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

- 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.

2.2 NONMETALLIC 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. Anamet Electrical, Inc.
 4. Arnco Corporation.
 5. CANTEX Inc.
 6. CertainTeed Corp.
 7. Condux International, Inc.
 8. Electri-Flex Company.
 9. Kraloy.
 10. Lamson & Sessions; Carlon Electrical Products.
 11. Niedax-Kleinhuis USA, Inc.
 12. RACO; a Hubbell company.
 13. Thomas & Betts Corporation.
- 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-B.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651B.
- F. RTRC: Comply with UL 1684A and NEMA TC 14.
- G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- I. Solvent cements and adhesive primers 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."

2.3 METAL 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. Cooper B-Line, Inc.
 - 2. Hoffman; a Pentair company.
 - 3. Mono-Systems, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R or Type 4 as 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-B.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type, for larger than 6x6 inch, Screw-cover type, for 6x6 inch and smaller and Flanged-and-gasketed type in dusty and outdoor conditions, unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

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. Allied Moulded Products, Inc.
 - 2. Hoffman; a Pentair company.
 - 3. Lamson & Sessions; Carlon Electrical Products.
 - 4. Niedax-Kleinhuis USA, Inc.
- 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-B.
- 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. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- G. Solvent cements and adhesive primers 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."

2.5 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-B.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.
 - 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. Mono-Systems, Inc.
 - b. Niedax-Kleinhuis USA, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.

2.6 BOXES, ENCLOSURES, AND CABINETS

- 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. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. Hoffman; a Pentair company.
 - 6. Hubbell Incorporated; Killark Division.
 - 7. Lamson & Sessions; Carlon Electrical Products.
 - 8. Milbank Manufacturing Co.
 - 9. Molex; Woodhead Brand.

10. Mono-Systems, Inc.
11. O-Z/Gedney; a brand of EGS Electrical Group.
12. RACO; a Hubbell company.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. 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.

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

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

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

F. Device Box Dimensions: 4 11/16 inches square by 2-1/2 inches deep (120 mm square by 65 mm deep).

G. Gangable boxes are prohibited.

H. 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: Stainless Steel at least 360.
2. Nonmetallic Enclosures:
 - a. Material: Plastic or Fiberglass.
 - b. Finished inside with radio-frequency-resistant paint.

I. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box indoors, Type 4X outdoors 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.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with TIA-569-B.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "COMMUNICATIONS."
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

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 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: RNC, Type EPC-40-PVC, 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 or IMC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 5. Damp or Wet Locations: GRC IMC.
 - 6. 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, unless noted otherwise: 1-inch (25-mm) trade size. Minimum size for optical-fiber cables is 1 ¼-inch (32 mm).
- 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 or compression, steel fittings. Comply with NEMA FB 2.10.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B 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 (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and below 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 two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.
- 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 (300 mm) of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 2 inches (50 mm) 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 or IMC 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 assembling conduit to enclosure to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch (53-mm) 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 (90-kg) tensile strength. Leave at least 12 inches (300 mm) 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 telecommunications outlet boxes only where indicated on Drawings.
 - 2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
 - 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 1-Inch (25-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
 - 2. 1 1/4-Inch (32-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- T. 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.
- U. 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.
- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- W. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT 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.
 - d. Attics: 135 deg F (75 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 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.
- X. Mount boxes at heights to match those indicated on Electrical Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements.
- 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.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

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

- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- E. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Wire-basket cable trays.
 - 2. Trough cable trays.
- 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.
- 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. Include 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."
 2. Component Importance Factor: 1.0..
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

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 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. [Cablofil/Legrande](#).
 2. [Chalfant Manufacturing Company](#).
 3. [Cooper B-Line, Inc.](#)
 4. [Enduro Systems, Inc.](#)
 5. [Mono-Systems, Inc.](#)
 6. [MP Husky](#).
 7. [Niedax-Kleinhuis USA, Inc.](#)
 8. [Snaketray](#).
 9. [WBT, LLC](#).
 10. [Wiremaid Products Division; Vutec Corporation](#).
- 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. Wire-Basket Depth: **4-inch (100-mm)** usable loading depth by **24 inches (600 mm)** wide, unless otherwise noted.
 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: ASTM F 593 and ASTM F 594 stainless steel, Type 316.

2.4 MATERIALS AND FINISHES

- A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Hot-dip galvanized after fabrication.
 - a. Standard: Comply with ASTM A 123/A 123M, Class B2.
 - b. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594..

B. Aluminum:

1. Materials: Alloy 6063-T6 according to ANSI H 35.1/H 35.1M for extruded components and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H 35.1/H 35.1M for fabricated parts.
2. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
3. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

C. Stainless Steel:

1. Materials: Low-carbon, passivated, stainless steel, Type 304L or Type 316L, ASTM F 593 and ASTM F 594.
2. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

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-~~ (40-mm-) 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 (90 kg)**. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details according to Section 260548 "Vibration and 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 or wall brackets.
- N. Support trapeze hangers for wire-basket trays with **3/8-inch- (10-mm-)** diameter rods.
- O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

- P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA 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 260526 "Grounding and Bonding for Electrical Systems."
- B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.

- B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).
- E. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
 - 4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
 - 5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorqued 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 271200 - COMMUNICATIONS 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. Pathways.
 - 2. UTP cable.
 - 3. Single-mode optical fiber cabling.
 - 4. Multi-mode optical fiber cabling.
 - 5. Multiuser telecommunications outlet assemblies.
 - 6. Cable connecting hardware, patch panels, and cross-connects.
 - 7. Telecommunications outlet/connectors.
 - 8. Cabling system identification products.
 - 9. Cable management system.
- B. Related Sections:
 - 1. Division 27 Section "Pathways for Communications systems" for pathways associated with voice and data cabling.
 - 2. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for cabling associated with electronic safety and security systems.

1.3 DEFINITIONS

- A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- B. BICSI: Building Industry Consulting Service International.
- C. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.
- D. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- E. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- F. EMI: Electromagnetic interference.
- G. FTP: Foil wrapped twisted pair.
- H. IDC: Insulation displacement connector.

- I. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- J. LAN: Local area network.
- K. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
- L. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- M. RCDD: Registered Communications Distribution Designer.
- N. STP: Shielded twisted pair.
- O. Solid-Bottom or Non-ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.
- P. TO: Telecommunications Outlet, the individual port(s) installed for the connection of digital equipment.
- Q. TR: Telecommunications Room, the room where the horizontal cable originates and typically contains the "active" network components, which provide network connectivity to the outlets and ports.
- R. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.
- S. UTP: Unshielded twisted pair.
- T. WAO: Work Area Outlet, the telecommunications faceplate with ports in a work area location, a work area is typically approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

1.4 BACKBONE CABLING DESCRIPTION

- A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities.

1.5 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.
 - 1. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.

- B. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the patch cord length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include the patch cord allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

1.6 REFERENCE STANDARDS

- A. ANSI/TIA-492.AAAC-B – Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class 1a Graded-index Multimode Optical Fibers (OM3/OM4). Current Edition
- B. ANSI TIA-492.CAAB – Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak. Current Edition
- C. ANSI/TIA 526 – OFSTP-19 Optical Signal-to-Noise Ratio Measurement Procedures for Dense Wavelength-Division Multiplexed Systems.
- D. ANSI/TIA-568-C.0 – Generic Communications Cabling for Customer Premises..
- E. ANSI/TIA-568-C.1 – Commercial Building Communications Cabling Standard Part 1: General Requirements.
- F. ANSI/TIA 568-C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standards
- G. ANSI/TIA 568-C.3 – Optical Fiber Cabling Components Standard
- H. ANSI/TIA-569-C – Commercial Building Standard for Telecommunications Pathways and Spaces.
- I. ANSI/TIA-606-B – Administration Standard for the Commercial Telecommunications Infrastructure.
- J. ANSI/JSTD-607-C – Commercial Building Bonding and Grounding (Earthing) Requirements for Telecommunications.
- K. NFPA 70 – National Electrical Code (NEC).
- L. BICSI – TDMM, Building Industries Consulting Services International, Telecommunications Distribution Methods Manual (TDMM)

1.7 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. 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, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

3. Cabling administration drawings and printouts.
 4. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 6. 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. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration complete in faceplates for color selection and review of technical features.
- D. Qualification Data: For Installer, and qualified layout technician, installation supervisor, and field inspector.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Maintenance Data: For splices and connectors to include in maintenance manuals.
- H. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 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.

- D. 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.
- E. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- F. Grounding: Comply with ANSI-J-STD-607-A.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical loss test set.
 - 2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
 - 3. Test each pair of UTP cable for open and short circuits.

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 Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.12 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Patch-Panel Units: One of each type.
 - 2. Connecting Blocks: One of each type.
 - 3. Device Plates: One of each type.
 - 4. Multiuser Telecommunications Outlet Assemblies: One of each type.

1.13 WARRANTY

- A. The horizontal communications cabling system installed shall be eligible for coverage by a Limited Lifetime Warranty to the end user.
- B. Horizontal channels shall be completed with Manufacturer Network Solutions factory-terminated copper and/or fiber optic patch cords in order to be eligible for the applicable Manufacturer Warranty with channel performance guarantees.

- C. Approved product shall be listed on the most recent version of the applicable Manufacturer data sheets for each solution.
- D. Optimized Installer/Optimized Integrator shall provide labor, materials, and documentation in accordance with Manufacturer requirements necessary to ensure that the Owner will be furnished with a Limited Lifetime Warranty.
- E. The installed structured cabling system shall provide a warranty guaranteeing installed channel performance above the ANSI/TIA 568-C requirements for Cat 6, and Cat 6A cabling systems.
- F. Standards-compliant channel or permanent link performance tests shall be performed in the field with a Manufacturer approved certification tester in the appropriate channel or permanent link test configuration. See 1.8 A.1 above for channel requirements.
- G. Necessary documentation for warranty registration shall be provided to the manufacturer by the installer (within 10 days) following 100 percent testing of cables.
- H. Submit test results to Manufacturer, in the certification tester's original software files.
- I. Installer shall ensure that the warranty registration is properly submitted, with all required documentation within 10 days of project completion.
- J. Optimized Contractor/Optimized Integrator must adhere to the terms and conditions of the respective manufacturer's warranty programs.
- K. Installer shall ensure that the Owner receives the manufacturer issued project warranty certificate within 60 calendar days of warranty registration.

PART 2 - PRODUCTS

2.1 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.
- B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 2. Lacing bars, spools, J-hooks, and D-rings.
 - 3. Straps and other devices.
- C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." **Flexible metal conduit shall not be used.**
 - 1. Outlet boxes shall be no smaller than 4 11/16 inch square, and 2-1/2 inches (64 mm) deep, with appropriate plaster/tile/surface ring to suit the box installation.

2.2 UTP CABLE

- A. Manufacturers: Basis of Design:
 - 1. Berk-Tek, a Nexans company.
 - a. Cat6A Standard;

- B. Alternate Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belden CDT Inc.; Electronics Division.
 2. Berk-Tek; a Nexans company.
 3. CommScope, Inc.
 4. Hitachi USA
 5. Mohawk; a division of Belden CDT.
 6. SYSTIMAX Solutions; a CommScope, Inc. brand.
 7. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- A. Category 6A Unshielded Twisted Pair: CX6500 Cat 6A Standard UTP System.
1. 100 ohm, Category 6A, 23 AWG, 4-pair unshielded twisted pair, LANmark-10G2, CMP rated.
 - a. Color: Blue.
 - b. Part Numbers: Reel: 10130484 Reel in Box: 11085339
 - c. Electrical Characteristics: Characterized to 750 MHz.
 - d. Cable: Third-party verified by ETL.
 - e. Maximum Cable Diameter: 0.300 inch.
 - f. Berk-Tek LANmark-10G2 CMP.
 2. Channel margin guarantees for a CX6500 Cat 6A Standard UTP System (margin vs. ANSI/TIA-568-C.2 and margin guarantees are for a 4-conductor channel).
 - a. Insertion Loss 3 %
 - b. NEXT 2 dB
 - c. PSNEXT 3 dB
 - d. ACR-F (ELFEXT) 5 dB
 - e. PSACR-F (PSELFEXT) 6 dB
 - f. Return Loss 1 dB
 - g. ACR-N 4 dB
 - h. PSACR-N 5 dB
 - i. PSANEXT 0 dB
 - j. PSAACR-F 0 dB

2.3 UTP CABLE HARDWARE

- A. Manufacturers: Basis of Design:
1. Leviton Voice & Data Division.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Premise Wiring.
 2. Leviton Voice & Data Division.
 3. Molex Premise Networks; a division of Molex, Inc.
 4. Panduit Corp.
 5. Siemon Co. (The).
 6. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
- C. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- D. Connecting Blocks (wall mounted): 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25percent spare. Integral with connector bodies, including plugs and jacks where indicated.

- E. Cross-Connect (Patch Bay mounted): Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
- F. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - 1. Number of Jacks per Field: [One] <Insert number> for each four-pair [UTP cable indicated] [conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria].
- G. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
 - 1. Category 6A Modular Jacks: CX6700 Cat 6A Enhanced+ UTP System or CX6500 Cat 6A Standard UTP System.
 - a. 8-position eXtreme QuickPort modular jack, Category 6A, IDC terminals, T568A/B wiring scheme.
 - b. Channel-rated jack.
 - c. Each Jack: Identified on its face as CAT 6A.
 - d. Color: white.
 - e. Part Number: Leviton 6110G-RW6 (white).
- H. Patch Cords: Factory-made, four-pair cables in 36-inch (900 mm) and 48-inch (1200-mm), 50% of each length for a total to match the number of installed horizontal cables; terminated with eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall be color coded and have color-coded boots for circuit identification.

2.4 OPTICAL FIBER CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berk-Tek; a Nexans company.
 - 2. CommScope, Inc.
 - 3. Corning Cable Systems.
 - 4. Mohawk; a division of Belden CDT.
- B. Optical Fiber Cable. **OM4 Fiber Optic System:**
 - 1. Each Multimode Fiber shall be:
 - a) Graded-index optical fiber wave-guide with nominal **50/125µm**-core/cladding diameter.
 - b) The fiber shall comply with the latest revision of ANSI/EIA/TIA-492AAAD.
 - c) Attenuation shall be measured in accordance with ANSI/EIA/TIA-455-78.
 - d) Information transmission capacity shall be measured in accordance with the latest revision of ANSI/EIA/TIA-455-204.
 - e) The measurements shall be performed at 23°C ± 5°C.
 - f) Maximum attenuation dB/km @ 850/1300 nm: 3.0/1.0
 - g) EMB Bandwidth 4700 MHz-km @ 850nm.
 - h) OFL Bandwidth 500 MHz-km @ 1300nm.
 - i) Optical Fiber shall be Bend-insensitive Laser Optimized and guarantee 1Gigabit Ethernet distances of 1040m/600m for 850nm and 1300nm, respectively.
 - j) Optical fiber shall guarantee a 10 Gigabit Ethernet distance of 550m at 850nm

2. Physical Characteristics:
 - a) Shall be suitable for use in indoors or in indoor/outdoor applications.
 - b) Appropriately flame rated optical cable shall be suitable for use in risers, plenums and horizontal applications.
 - c) Plenum rated optical cables shall have and be marked with an UL-OFNP and OFN FT6 Flame Rating. Riser rated optical cables shall have and be marked with an UL-OFNR and OFN FT4 Flame Rating
 - d) Shall comply with the requirements of ICEA S-83-596 (Premises), ICEA S-104-696 (I/O), or ANSI/ICEA S-87-640 (Outside Plant, OSP).
 - e) Suitable for underground or aboveground conduits.
 - f) Optical cables and fibers shall be color coded in accordance with EIA/TIA-598-C.
 - g) Shall have a ripcord for overall jacket.
 3. Design Make:
 - a) **Berk-Tek Plenum optical fiber cable with OM4 Bend-insensitive Laser Optimized 50/125 micron fiber**
 - LTPxxxFB3010/F5, (006 to 012 Bend-insensitive Laser Optimized optical fibers, I/O Loose Tube)
 - LTP12BxxxFB3010/F5, (012 to 432 Bend-insensitive Laser Optimized optical fibers, I/O Loose Tube)
 - PDPxxxFB3010/F5 (006 to 024 Bend-insensitive Laser Optimized optical fibers, Indoor Tight Buffer)
 - PDP12BxxxFB3010/F5, (036 to 144 Bend-insensitive Laser Optimized optical fibers, Indoor Tight Buffer)
 - b) **Berk-Tek Riser optical fiber cable with OM4 Bend-insensitive Laser Optimized 50/125 micron fiber**
 - LTRxxxFB3010/F5, (006 to 012 Bend-insensitive Laser Optimized optical fibers, I/O Loose Tube)
 - LTR12BxxxFB3010/F5, (012 to 432 Bend-insensitive Laser Optimized optical fibers, I/O Loose Tube)
 - PDRxxxFB3010/F5 (006 to 024 Bend-insensitive Laser Optimized optical fibers, Indoor Tight Buffer)
 - PDR12BxxxFB3010/F5, (036 to 144 Bend-insensitive Laser Optimized optical fibers, Indoor Tight Buffer)
- C. Single-Mode Optical Fiber Cable. **OS2 Fiber Optic System:**
1. Each Single-mode Fiber shall be:
 - a) Dispersion - unshifted single mode optical fibers with Low Water Peak complying with ITU-T G.652.D and with improved bending loss complying with ITU-T G.657.A1.
 - b) The zero dispersion wavelength shall be between 1300 nm and 1320 nm. The ANSI/EIA/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm². Dispersion measurements shall be made in accordance with ANSI/EIA/TIA-455-169 or ANSI/EIA/TIA-455-175-B.
 - c) The nominal mode field diameter shall be 9.2 μ m with a tolerance of $\pm 0.4 \mu$ m at 1310 nm when measured in accordance with ANSI/EIA/TIA-455-191-B.

- d) Transmission Characteristics:
 - e) Maximum cabled attenuation for loose tube fibers shall be 0.4/0.3 dB/km @ 1310/1550 nm.
 - f) Maximum cabled attenuation for tight buffer fibers shall be 0.7/0.7 dB/km @ 1310/1550 nm.
 - g) The cabled cutoff wavelength shall be ≤ 1260 nm when measured in accordance with ANSI/EIA/TIA-455-80-C.
2. Physical Characteristics:
- a) Shall be suitable for use in indoors or in indoor/outdoor applications.
 - b) Appropriately flame rated optical cable shall be suitable for use in risers, plenums and horizontal applications.
 - c) Plenum rated optical cables shall have and be marked with an UL-OFNP and OFN FT6 Flame Rating. Riser rated optical cables shall have and be marked with an UL-OFNR and OFN FT4 Flame Rating
 - d) Shall comply with the requirements of ICEA S-83-596 (Premises), ICEA S-104-696 (I/O), or ANSI/ICEA S-87-640 (Outside Plant, OSP).
 - e) Suitable for underground or aboveground conduits.
 - f) Optical cables and fibers shall be color coded in accordance with EIA/TIA-598-C.
 - g) Shall have a ripcord for overall jacket.
3. Design Make:
- a) **Berk-Tek Plenum optical fiber cable with OS2 (Low Water Peak) Bend-insensitive Singlemode fiber**
 - LTPxxxAB0403, (006 to 012 Bend-insensitive optical fibers, I/O Loose Tube)
 - LTP12BxxxAB0403, (012 to 432 Bend-insensitive optical fibers, I/O Loose Tube)
 - PDPxxxAB0707 (006 to 024 Bend-insensitive optical fibers, Indoor Tight Buffer)
 - PDP12BxxxAB0707, (036 to 144 Bend-insensitive optical fibers, Indoor Tight Buffer)
 - b) **Berk-Tek Riser optical fiber cable with OS2 (Low Water Peak) Bend-insensitive Singlemode fiber**
 - LTRxxxAB0403, (006 to 012 Bend-insensitive optical fibers, I/O Loose Tube)
 - LTR12BxxxAB0403, (012 to 432 Bend-insensitive optical fibers, I/O Loose Tube)
 - PDRxxxAB0707 (006 to 024 Bend-insensitive optical fibers, Indoor Tight Buffer)
 - PDR12BxxxAB0707, (036 to 144 Bend-insensitive optical fibers, Indoor Tight Buffer)
- B. Jacket:
- 1. Jacket Color:
 - 2. Aqua for 50/125-micrometer cable.
 - 3. Orange for 62.5/125-micrometer cable.
 - 4. Yellow for 8.7/125-micrometer cable.

5. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
6. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

2.5 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ADC.
 2. Berk-Tek; a Nexans company.
 3. Corning Cable Systems.
 4. Siemon Co. (The).
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
 1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit 25% expansion.
- C. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
- D. Cable Connecting Hardware:
 1. QuickPort Simplex SC Adapter for multimode fiber, phosphor-bronze sleeve.
 - a. Color of plastic housing: white
 - b. Part Number: Leviton 41085-MWC (white).
 2. QuickPort Duplex LC Adapter, blue adapter for OS1/OS2 Single Mode fiber, zirconia ceramic sleeve.
 - a. Color of plastic housing: white
 - b. Part Number: Leviton 41085-SLW (white).

2.6 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Chatsworth Products, Inc.
 2. Molex Premise Networks; a division of Molex, Inc.
 3. Ortronics, Inc.
 4. Panduit Corp.
 5. Siemon Co. (The).
- B. Description: MUTOAs shall meet the requirements for cable connecting hardware.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
 2. Number of Connectors per Field:
 - a. One for each four-pair UTP cable indicated.
 - b. One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
 3. Mounting: [Recessed in ceiling] [Wall] [Desk] [Furniture].
 4. NRTL listed as complying with UL 50 and UL 1863.
 5. Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
 6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.7 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.

- B. Workstation Outlets: Number of ports as indicated on the drawings, connector assemblies mounted in faceplate(s) as indicated on the drawings.
1. Faceplates: Stainless Steel (painted, brushed, or polished), brass, or high-impact plastic, to match the electrical devices in the same area. Coordinate color with Division 26 Section "Wiring Devices."
 2. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
 3. Legend: Factory labeled by silk-screening or engraving for stainless steel and brass faceplates.
 4. Legend: Snap-in, clear-label covers and machine-printed paper inserts for plastic faceplates.

2.8 JUMPERS

- A. UTP Jumpers
1. Slim-Line style, Category 6A, shielded cord (use same cord for shielded or unshielded systems) 4-pair, stranded wire construction.

Provide the following quantity of Jumpers in the lengths and colors noted, the total number of Jumpers shall be equal to twice (2X) the total number of faceplate ports.

Type/color	3 feet	5 feet	7 feet	10 feet	15 feet	20 feet
UTP						
Blue						
Yellow						
Green						
White						
Red						
Gray						

- B. Fiber Optic Jumpers

2. OM3, aqua. Factory-terminated, double-ended, 2-strand multimode cordage. Use for **OM3 Fiber Optic System, OM4 Fiber Optic System, or OM4+ Fiber Optic System**
3. Duplex SC-Duplex SC:
4. Single Mode Fiber Optic Jumpers:
5. OS1/OS2, yellow. Factory-terminated, double-ended, 2-strand multimode cordage, UPC polish. Use for **OS2 Fiber Optic System**
 - a. Duplex LC-Duplex LC:

Type/color	1 meter	2 meter	3 meter	5 meter	10 meter	
OM1						
OM2						
OM3/4/4+						
OS1/OS2						

2.9 GROUNDING

- A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Comply with requirements in Division 27 Section "Grounding and Bonding for Telecommunications systems."
- C. Comply with ANSI-J-STD-607-C.

2.10 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.11 CABLE MANAGEMENT SYSTEM

- A. Description: Computer-based cable management system, in tabular form in Microsoft Excell or other file format approved by the Owner.
- B. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.
- C. Information shall be presented in spreadsheet format, schematic plans, or technical drawings.
 - 1. Microsoft Visio Professional or AutoCAD drawing software shall be used as drawing and schematic plans software.
- D. Data shall correlate and correspond to the following testing and recording devices:
 - 1. Direct upload tests from circuit testing instrument into the personal computer.

2.12 SOURCE QUALITY CONTROL

- A. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- B. Factory test UTP cables according to TIA/EIA-568-B.2.
- C. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.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.
- 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 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, except in accessible ceiling spaces, in attics, where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings
 - 2. Install riser or plenum rated cable in all runs which traverse vertically 2 or more floors.
 - 3. All cables shall be indoor rated, except entrance cables which may be outdoor rated cable for not more than 50 (cable)feet inside a building.
 - 4. Comply with requirements for raceways and boxes specified in Division 27 Section "Raceway and Boxes for Telecommunications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
- C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- E. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- F. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard when entering room from overhead.
 - 4. Extend conduits 3 inches (76 mm) above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CABLES

- A. Comply with NECA 1.

- B. General Requirements for Cabling:
1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Install 110-style IDC termination hardware unless otherwise indicated.
 4. MUTOA shall not be used as a cross-connect point.
 5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - 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 UTP at least 49 feet (15 m) from communications equipment room.
 6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 10. 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.
 11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 12. In the communications equipment room, install a 10-foot- (3-m-) long service loop and at the "Workstation" end provide a 3-foot (1-m) service loop.
 13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.2.
 2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- D. Optical Fiber Cable Installation:
1. Comply with TIA/EIA-568-B.3.
 2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- E. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- 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. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
- G. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
- H. Group connecting hardware for cables into separate logical fields.
- I. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
 4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping."
- B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with ANSI-J-STD-607-C.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 1. Administration Class: 4.
 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 4 level of administration, including optional identification requirements of this standard.
- E. Cable Schedule: Post in 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.
- F. 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. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- G. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 4. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 - 5. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
- H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
 - 1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.

2. Visually confirm specified Category marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 5. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 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.
 6. UTP Performance Tests:
 - a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Equal-level far-end crosstalk (ELFEXT).
 - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
 7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.
 8. Coaxial Cable Tests: Conduct tests according to Division 27 Section "Master Antenna Television System."
 9. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
 - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271500

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. Telecommunications mounting elements.
 - 2. Backboards.
 - 3. Telecommunications equipment racks and cabinets.
 - 4. Telecommunications service entrance pathways.
 - 5. Grounding.
- B. Related Sections:
 - 1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
 - 2. Division 27 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
 - 3. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

- A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- B. BICSI: Building Industry Consulting Service International.
- C. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
- D. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- E. LAN: Local area network.
- F. RCDD: Registered Communications Distribution Designer.
- G. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
- H. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 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 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. 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.
- C. Qualification Data: For Installer(s), and qualified layout technician, installation supervisor, and field inspector.
- D. Seismic Qualification Certificates: For floor-mounted cabinets, 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. 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 the direct supervision of RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician or Level 2 Installer, 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 or Commercial Installer, Level 2 to perform the on-site inspection.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- D. Grounding: Comply with ANSI-J-STD-607-A.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.8 COORDINATION

- A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.
 - 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
 - 4. Adjust arrangements 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 the equipment room.
- B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.1 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.
- B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
 - 1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
 - 2. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 3. Lacing bars, spools, J-hooks, and D-rings.
 - 4. Straps and other devices.
- C. Cable Trays:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Chalfant.
 - b. Cooper B-Line, Inc.
 - c. Snake Tray
 - 2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by hot dip galvanizing, anodizing or power coating (no electro-galvanized tray shall be used in equipment rooms).

- a. Basket Cable Trays: 24 inch by 6 inch, unless noted otherwise on drawings. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
 - b. Trough Cable Trays: Aluminum, 24 inch by 6 inch, unless noted otherwise on drawings. Ventilated with rolled edge slots 6 inch on center
 - c. Cable Ladder: 18 inches (455 mm) wide, and a rung spacing of 6 inches (150 mm), unless noted otherwise on drawings.
 - d. Channel Cable Trays: One-piece construction, aluminum, nominally 6 inches (150 mm) wide, unless otherwise noted on drawings. Solid bottom.
- D. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." **Flexible metal conduit shall not be used.**
1. Outlet boxes shall be 4 11/16 square by 2 ½ inches deep, with plaster, tile or surface "ring" to suit installation.

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, A-C, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry." Mount A side facing the room and paint to match Wall Finish Schedule, after field verification of "fire Retardant" stamps.

2.3 EQUIPMENT FRAMES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ADC.
 2. Chatsworth Products.
 3. Cooper B-Line, Inc.
 4. Great Lakes Enclosure
 5. Hoffman
 6. Hubbell Premise Wiring.
 7. KRONE Incorporated.
 8. Middle Atlantic Products, Inc.
- B. General Frame Requirements:
1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 2. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.
 3. Finish: Manufacturer's standard, baked-polyester powder coat.
- C. Floor-Mounted "Relay" Racks: Modular-type, steel or aluminum construction.
1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and two power strips.
 2. Baked-polyester powder coat finish.
- D. Modular Freestanding Cabinets:
1. Removable and lockable side panels.
 2. Hinged and lockable front and rear doors.
 3. Adjustable feet for leveling.
 4. Screened ventilation openings in the roof and rear door.
 5. Cable access provisions in the roof and base.
 6. Grounding bus bar.

7. Roof-mounted, 550-cfm (260-L/s) fan with filter.
8. Power strip.
9. Baked-polyester powder coat finish.
10. All cabinets keyed alike.

E. Modular Wall Cabinets:

1. Wall mounting.
2. Steel or aluminum construction.
3. Treated to resist corrosion.
4. Lockable front doors.
5. Louvered side panels.
6. Cable access provisions top and bottom.
7. Grounding lug.
8. Roof-mounted, 250-cfm (118-L/s) fan.
9. Power strip.
10. All cabinets keyed alike.

F. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable managers as indicated on drawings, or not less than 6-2RU managers per rack and cabinet.
5. Closure panels on all unused RU's of space.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Rack mounting.
2. Six, 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
3. LED indicator lights for power and protection status.
4. LED indicator lights for reverse polarity and open outlet ground.
5. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
6. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
7. Cord connected with 15-foot (4.5-m)] line cord.
8. Rocker-type on-off switch, illuminated when in on position.
9. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
10. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

2.5 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:

1. Connectors: Mechanical type, cast silicon bronze, exothermic or solderless 2-hole, 2-crimp compression wire terminals, with long-barrel(2-crimp), two-bolt connection to ground bus bar.
2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

- C. Comply with ANSI-J-STD-607-A.

2.6 LABELING

- A. Comply with TIA/EIA-606-A 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 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- B. Install underground, buried, and/or aerial pathways, where indicated on drawings, complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.

3.2 Install entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems." INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- 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.

3.3 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with ANSI-J-STD-607-A.
- 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.

1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.5 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 4 level of administration including optional identification requirements of this standard.
- C. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 27 51 10 – AUDIO-VIDEO INTERCOM AND ACCESS SYSTEM – VERSATILE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Audio Video Intercom and Entry system.

1.2 RELATED SECTIONS

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

1.3 REFERENCES

- A. American National Standards Institute (ANSI): ANSI/TIA/EIA 568 - Commercial Building Telecommunications Cabling Standard.
- B. International Organization for Standards (ISO): ISO 9001 - Quality Management Systems - Requirements.

1.4 SYSTEM DESCRIPTION

- A. General: Audio-Video Intercom and Entry System (AVIC).
 - 1. The AVIC shall be used as an audio intercom and video door entry system as indicated.
 - 2. The system shall be comprised of master stations, audio and video door stations. Sub stations shall be installed in locations indicated or required for complete installation.
 - 3. The AVIC shall be an IP based system, allowing future expansion.
 - 4. The AVIC shall have a feature that permits customization by plugging in additional control units and door stations through the AVIC network.
 - 5. The AVIC shall include control unit functions, including basic conversation, and call forwarding.
 - 6. The AVIC shall have the following Substation types: vandal resistant, handset indoor use, flush mount, and surface mount types as scheduled, indicated or required.
- B. System Capacity: Refer to drawings for locations.
 - 1. Local (Analog) System:
 - a. 2 Master stations.
 - b. 2 Video Door stations.
 - c. System Capability:
 - 2. Video, Audio, and Data Logging:
 - a. PC archives.
 - b. Record video and audio from door stations.
 - 3. Master Station:
 - a. Pan-tilt zoom and wide video monitoring function.
 - b. Master station with 3.5 inch display for operation and video monitoring.
 - c. Hands-free or handset audio communication.
 - 4. Outside Line Communication:
 - a. One telephone line, call transfer to up to three telephone numbers.
 - b. Door and room sub stations to outside telephone line communication.

5. External Audio Input:
 - a. Multiple activation inputs with 2 audio inputs for external source distribution.
 6. Audio Distribution Scheduling:
 - a. Up to 1 year scheduling for calendar schedule.
 - b. Up to 20 daily events can be programmed.
 - c. Individual scheduled activation can also be set one time or daily.
- C. System Functions:
1. Call-Related Functions:
 - a. Video Door Station Call: A designated group of up to 20 master stations can be called from any video door station; any designated master can answer the call. 170 degrees view from the door station camera can be viewed from the master station, and zoom and pan/tilt operations are functional.
 2. Transfer-Related Function:
 - a. Call (Communication) Transfer: A master station can transfer a conversation to any master station within the system.
 3. Call Forwarding-Related Functions:
 - a. Call Forwarding: Incoming calls can be automatically forwarded to another receiving station or telephone. The receiving station number or telephone number can be registered at the original forwarding station. Unit number will be assigned to each telephone number.
 - b. Time-Based Call Forwarding: All incoming calls to the original station can be automatically rerouted to a designated master station or telephone number during a specific period of the day.
 - c. No Answer Call Forwarding: Calls to the original station are automatically rerouted to a designated receiving station if the called party does not respond within a preset period of time.
 4. Monitoring-Related Functions:
 - a. Monitoring: Any door, room or substation can be monitored from a master station. A master station can also disable this function if monitoring is not necessary.
 - b. Scan Monitoring: Any pre-programmed door stations or room sub stations (Maximum 20) can be scan monitored.
 5. Telephone-Related Functions:
 - a. Outgoing Telephone Calls: Outside telephone lines can be connected to the IS system, permitting calls from room subs and doors to be forwarded to an outside telephone line.
 - b. Pre-Recorded Audio File Paging Via Telephone: Pre-recorded audio file can be distributed to programmed paging zones or stations via the telephone.
 - c. Time-Based Outside Line Call Forwarding: Three telephone numbers can be pre-programmed to be forwarded if the called party does not respond within a preset period of time.

1.5 SUBMITTALS

- A. Submit under provisions of Division 01.
- B. Product Data: Manufacturer's data sheets on each product to be used, including.
 1. Preparation instructions and recommendations.
 2. Storage and handling requirements and recommendations.
 3. Installation methods.
- C. Shop Drawings: Submit the following:
 1. Wiring Diagrams: Indicate wiring for each item of equipment and interconnections

- between items of equipment.
- 2. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

- D. Installation and Operation Manuals:
 - 1. Submit manufacturer's installation and operation manual, including operation instructions and component wiring diagrams.
 - 2. Provide detailed information required for Owner to properly operate equipment.
- E. Warranty: Submit manufacturer's standard warranty.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001:2000 certified company.
- B. Installer Qualifications: Minimum 2 years experience installing similar equipment.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.
- B. Storage: Store materials in clean, dry area indoors in accordance with manufacturer's instructions.
- C. Handling: Protect materials during handling and installation to prevent damage.

1.8 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer:
 - 1. Aiphone Corp.
 - 2. N2
 - 3. Zenitel.

2.2 COMPONENTS

- A. Control Unit:
 - 1. Analog Control Unit.
 - a. Power Source: 48V DC (supplied from the power supply unit)
 - b. Current Consumption: Maximum 105mA
 - c. Talk Channels/ Video Channels/ Other Channels: 2 talk and 2 constrained video channels, 1 chime, and 1 telephone.
 - d. Central Control Unit: 1.
 - e. Mounting: Wall mount.
 - f. Ambient Temperature: 0 - 40 degrees C (+32 degrees F - +104 degrees F).
 - g. Material: Steel plate.

- B. Color Monitor Master Station:
1. Product: Color monitor master station.
 - a. Power Source: 24V DC.
 - 1) Current Consumption: Maximum 65 mA.
 - b. Power Source: 24V DC (supplied from the power supply unit).
 - 1) Current Consumption: Maximum 130 mA.
 - c. Communication:
 - 1) Handset: Simultaneous communication (When press-to-talk (PTT) is not set)
 - 2) Hands-free: Auto-voice actuation or Press-to-talk (PTT).
 - d. Monitor: 3.5 inch (89 mm) color LCD monitor.
 - e. Call Record: 20.
 - f. Reception Record: 20.
 - g. Paging Capacity: Simultaneous paging to Maximum 5 zones/stations.
 - h. Mounting: Desktop use, with stand.
 - i. Ambient Temperature: 0 - 40 degrees C (+32 degrees F - +104 degrees F).
 - j. Material: Flame resisting ABS resin.
 - k. Color: Black.
- C. Door Station:
1. Vandal-resistant video door station (flush-mount).
 - a. Power Source: 24V DC.
 - 1) Current Consumption: Maximum 85 mA.
 - b. Power Source: 24V DC (supplied from the power supply unit).
 - 1) Current Consumption: Maximum 160 mA.
 - c. Communication: Open voice hands-free communication.
 - d. Ambient Temperature: -10 - 60 degrees C (+14 degrees F - +140 degrees F).
 - e. Camera: 1/4-inch (6 mm) color CMOS.
 - f. Minimum Illumination: 5 Lux.
 - g. Camera Angle: Wide, approximately 170 degrees (horizontal).
 - h. Mounting: Flush-mount.
 - i. Electrical Box: Mounts on built-in back box.
 - j. Front Panel: Stainless steel, vertical hair-line processed.
 - k. Main Unit: Flame resisting PC+ABS resin.
 - l. Color, Back box: Black.
 - m. Description: Weather-resistant.
- D. Power Supply:
1. Power Supply Unit.
 - a. Power Source: AC 100 - 240V, 50/60Hz.
 - b. Power Consumption: 120W.
 - c. Secondary Output Voltage: DC 48V.
 - d. Secondary Output Current: 2.1 A.
 - e. Mounting: Wall.
 - f. Material: Steel plate.
 - g. Color: Black.
 - h. Ambient Temperature: 0 to 40 degrees C (+32 degrees F to +104 degrees F).

2.3 OPERATION

- A. When a call is placed, the master shall sound the announcement tone, the operator can answer or let the call transfer. The operator shall be able to release the door from the Master Station via an interface with the access Control System.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive video entry system.
- B. Notify Architect of conditions that would adversely affect installation or subsequent use.
- C. Do not begin installation until unacceptable conditions are corrected.

3.2 INSTALLATION

- A. Install video entry system in accordance with manufacturer's instructions at locations indicated on the Drawings.
- B. Mount equipment plumb, level, square, and secure.
- C. Cables:
 - 1. Run cables from and homerun to one central location where CEU will be installed.
 - 2. Maintain twists of cable pairs to point of termination or no more than 0.5 inch (13 mm) untwisted.
 - 3. Do not remove more than 1 inch (25 mm) of jacket when terminating cables.
 - 4. Cable Bends:
 - a. Make gradual bends of cable, where necessary.
 - b. Do not make bends of cable sharper than 1 inch (25 mm) radius.
 - c. Do not allow cable to be sharply bent or kinked at any time.
 - 5. Cable Ties: Dress cables neatly with cable ties using low to moderate pressure.
 - 6. Cross-connect cables, where necessary, using CAT-5e rated punch blocks and components.
 - 7. Do not splice or bridge cables.
 - 8. Cable Pulling:
 - a. Pull cable with low to moderate force.
 - b. Do not use oil or other lubricants not specifically designed for cable pulling.
 - 9. Keep cables as far away from potential sources of EMI as possible.
 - 10. Do not tie cables to electrical conduits or lay cables on electrical fixtures.
 - 11. Cable Supports:
 - a. Install proper cable supports a maximum of 5 feet (1524 mm) apart.
 - b. Do not support cables by ceiling tiles.
 - 12. Label Cable Termination Points: Use unique number for each cable segment.
 - 13. Testing Cables: Test installed cable segments with cable tester.
 - 14. Jacks: Install jacks to prevent dust and other contaminants from settling on contacts.
 - 15. Cable Slack:
 - a. Leave extra slack on cables, neatly coiled-up in ceiling or nearest concealed place.
 - b. Leave a minimum of 1 foot (305 mm) of cable slack at door station side and a minimum of 10 feet (3048 mm) of cable slack at CEU side.
 - 16. Do not install cables taught.
 - 17. Grommets: Protect cables with grommets where passing through metal studs or other items that could damage cables.
 - 18. Do not mix TIA/EIA 568A and 568B wiring on same installation. Use TIA/EIA 568B wiring throughout installation.
 - 19. Staples:
 - a. Do not use staples that crimp cables tightly.
 - b. Do not use T-18 and T-25 cable staples.

20. Firestop cables that penetrate firewalls.
21. Use plenum-rated cable.

3.3 ADJUSTING

- A. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.4 DEMONSTRATION AND TRAINING

- A. Demonstration:
 1. Demonstrate that integrated security and communication system functions properly.
 2. Perform demonstration at final system inspection by qualified representative of manufacturer.
- B. Instruction and Training:
 1. Provide instruction and training of Owner's personnel as required for operation of integrated security and communication system.
 2. Provide hands-on demonstration of operation of system components and complete system, including user-level program changes and functions.
 3. Provide instruction and training by qualified representative of manufacturer.

3.5 PROTECTION

- A. Protect installed integrated security and communication system from damage during construction.

END OF SECTION

SECTION 275313 – WIRELESS CLOCK SYSTEM

PART 1 - GENERAL

1.1 Section Includes

- A. Transmission System
 - 1. System Controller with Receiver (GPS, CDMA, Ethernet)
 - 2. Primary Internal Transmitter
- B. Wireless Synchronized Devices
 - 1. Analog Clocks. Digital Clock
 - 2. Master Clock Synchronizer

1.2 Related Divisions and Sections

- A. Division 26 - Electrical 120V for 60Hz grounded power required for System Master Equipment.

1.3 References

- A. National Fire Protection Agency (NFPA) – 70, National Electric Code 2005

1.4 Definitions

- A. (GPS): Global Positioning System A worldwide system that employs 24 orbiting satellites in an integrated network to determine geographic location anywhere in the world, and which employs and transmits atomic time.
- B. (CDMA): Code Division Multiple Access: A time synchronization used in the mobile telephone industry.
- C. Ethernet: Provides time synchronization via SNTP (Simple Network Time Protocol) or Day-time Protocol from time server.

1.5 Submittals

- A. Product Data: Submit complete catalog data for each component, describing physical characteristics and method of installation. Submit brochure showing available colors and finishes of clocks.
- B. Operating License (if required): Submit evidence of application for operating license prior to installing equipment. Furnish the license, or if the license has not been received, a copy of the application for the license, to the Owner prior to operating the equipment. When license is received, deliver original license to Owner.
- C. Samples: Submit one clock for approval. Approved sample shall be tagged and shall be installed in the work at location directed.

- D. Manufacturer's Instructions: Submit complete installation, set-up and maintenance instructions.

1.6 Quality Assurance

A. Qualifications:

1. Manufacturer: Company specializing in manufacturing commercial timekeeping systems with a minimum of 10 continuous years of documented experience.
2. Installer: Company with documented experience in the installation of commercial timekeeping systems.

1.7 Regulatory Requirements

- A. Equipment and components furnished shall be of manufacturer's latest model.
- B. System Controller, Transmitter and receiver shall comply with Part 90 of FCC rules, as follows:
 1. This device may not cause harmful interference.
 2. Transmitter frequency shall be governed by FCC Part 90.35.
 3. Transmitter output power shall be governed by FCC Parts 90 and 74.
- C. System shall be installed in compliance with local and state authorities having jurisdiction.
- D. Permits: Obtain operating license for the transmitter from the FCC. (FCC licensing can be coordinated by system manufacturer)

1.8 Delivery, Storage and Handling

- A. Deliver all components to the site in the manufacturer's original packaging. Packaging shall contain manufacturer's name and address, product identification number, and other related information.
- B. Store equipment in finished building, unopened containers until ready for installation.

1.9 Field Conditions

- A. Clocks shall not be installed until painting and other finish work in each room is complete.
- B. Coordinate installation of GPS receiver and external antenna for access to the roof or exterior side-wall so that the bracket and related fasteners are watertight.

PART 2 - PRODUCTS

2.1 Systems Description

- A. A basic wireless timekeeping system, consisting of a system controller, a built-in or external transmitter, transmitter antenna, a means of receiving time synchronization (GPS, CDMA, Ethernet), analog clocks, and accessory or optional components for expanding the system and its operations, that is capable of synchronizing clocks and computers throughout the facility on a daily basis.
- B. System shall synchronize all clocks to each other. System shall utilize GPS, CDMA, or Ethernet technology to provide atomic time to components. System shall not require hard wiring for its components except for AC power. Analog clocks may be battery operated for full portability if required. Clocks shall automatically adjust for Daylight Saving Time per the Daylight Saving time settings in the system controller.

- C. Analog Clocks shall synchronize to +/- 1 second of the master clock displayed time.
- D. The system shall include an internal real time clock reference so that failure of the GPS signal shall not cause the clocks to fail in indicating the correct time.
- E. The system shall incorporate a "fail-proof" design so that a temporary power interruption shall not cause failure of the system. Upon restoration of power, the system shall resume normal operation.
- F. The system shall include a optional notification pager or communication method to notify a local supervisor or maintenance personnel when the pager is active and the master is transmitting to verify signal reception.
- G. Analog clocks shall be battery operated for complete portability and relocation freedom, .
- H. System instruction manual and equipment shall be available for building site transmitter signal reception diagnosis.

2.2 Manufacturer

- A. Wireless timekeeping system and its components shall be manufactured by one of the following acceptable manufacturers:
 - 1. Primex.
 - 2. Bogen.
 - 3. American Time & Signal Company.
 - . Spectracom.

2.3 Equipment

- A. Wireless system controller: The system controller encoder shall incorporate a display and a keypad to provide the following features:
 - 1. Time zone selection via the keypad and display for all USA time zones as well as others requiring programming by American Time and Signal. Includes all US time zones: Eastern, Central, Mountain, Pacific, Alaska and Hawaii.
 - 2. Automatic Daylight Saving Time Adjustment can be enabled or disabled from keypad.
 - 3. GPS interface and real time GPS status display mode.
 - 4. Password protected Administrator Menu to set the date, local time zone, clock addresses, and other system parameters as needed.
 - 5. Database programming and administration using its keypad and LCD display
 - 6. The system controller shall contain an internal clock such that failure of reception from the GPS will not disable the operation of the clocks.
- B. GPS Receiver: GPS roof receiver with cable attached . The GPS Receiver shall be a complete GPS receiver with a built-in antenna, designed for roof or outdoor mounting. Provide mounting bracket for attachment to roof structure, CDMA antenna or connector for Ethernet synchronization.
- C. Transmitter: Wireless transmitters may be internal or external, up to 350 Watts. The transmitter parameters shall be:

1. Frequency Range: multiple frequencies acceptable but are specific to manufacturer
 2. Transmitter output power: Internal 1 - 5 Watt or External 10-350 Watt in external case
 3. Transmission Range: Up to 50 miles radius (transmitter dependent)
 4. Radio technology: Narrowband FM, 12.5 KHz bandwidth
 5. Transmission format: POCSAG, digital one-way communication
 6. Digital Data rate: 512 - 2400BPS
 7. Operating range: 0 degrees C. to 70 degrees
- D. Antenna: shall be for indoor or outdoor applications. Antenna polarization shall be dependent on manufacturer's recommendation.
- E. Power supply: (included with master),
1. Input: 120-volt AC 50/60 Hz
- F. Surge Protector/Battery Backup:
1. Input: 120-volt AC 60 Hz +/- 1 Hz.
 2. Output: 120-volt AC, 550VA, 300 watts
 3. Surge Energy Rating: 700 joules with 10x1000uS pulse
- G. Analog Clocks: Analog clocks, 12" diameter. Analog clocks shall be wall mounted. Clocks shall have polystyrene frame and polycarbonate lens . Face shall be white. Hour and minute hands shall be black, second hand is red. Other clock features shall be:
1. Analog clocks with no user mechanical adjustments. .
 2. Time shall be automatically updated from the transmitter with a minimum of 1 time per day.
 3. Use manufacturers recommended batteries .
 4. The clock shall have an ultra sensitive UHF receiver (better than -110dBm) and integrated internal antenna or other.
 5. The clock will keep operating using its internal quartz clock in case of signal reception loss due to malfunction of the wireless system controller or transmitter.
- 6.

2.4 Substitution Limitations

- A. Other systems requiring wiring and/or conduit between system controller and clocks will not be acceptable.

2.5 System Operation and Startup Sequence

- A. System shall receive Atomic Time information from GPS, CDMA or Ethernet that is connected to the system controller The system controller is a powerful multi-tasking device that is capable of

sending accurate time information to synchronize all the system wireless clocks and accessories. The system can be monitored and programmed from the system controller keypad and LCD.

B. Wireless System Controller Operation

1. When power is first applied to the system controller, it checks for and displays the software version and looks for the GPS time signal. Once the system controller has received the GPS time, it sets its internal clock to that time. The system controller then starts to transmit its internal time according to the specified time synchronization mode. The system controller updates its internal clock every time it receives valid time data from the GPS receiver.

C. Analog Clock Operation

1. For battery clocks, follow manufactures start up procedure to power up the clock.
2. After a few seconds of initial setup, the clock receiver will look for valid time transmission. The monitoring LED (if equipped) at the back of the clock will flash during that period of time. After a valid time data is received the monitoring LED will stop flashing, and the clock will adjust to the right time. The clock will look for valid time signals multiple times (minimum of once) each day, and will synchronize to the correct time if needed.

PART 3 - EXECUTION

3.1 Examination

- A. Verify that construction is complete in spaces to receive equipment and that rooms are clean and dry.
- B. Verify that 120-volt electrical outlet is located within 6 feet of location of transmitter and the outlet is operational and properly grounded.

3.2 Field Inspection

- A. Prior to final acceptance, inspect each system component to function properly and replace parts that are found defective.

3.3 Manufacturer Services

- A. If needed, provide technical assistance as demonstrated in the manufacturer's system user guide, on product start up and system setup, to owners or installers representatives via phone, fax, or e-mail.

3.4 System Installation

- A. Install in accordance with manufacturer's installation manual furnished with the system, for proper installation of each system component.
- B. Provide licenses for all clock system parts and transmitters, complete and filed with the appropriate government authority, ready for the Owner's use and maintenance.

3.5 Cleaning

- A. Prior to final acceptance, clean exposed surfaces of all system components, using cleaning methods recommended by the manufacturer.

END OF SECTION

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- Communications Backbone Cable
- C. Division 27- Communications Horizontal Cable
- D. Division 28- Pathways for Electronic Safety and Security

1.2 SUMMARY

- A. Section Includes:
 - 1. RS-232 cabling.
 - 2. RS-485 cabling.
 - 3. Low-voltage control cabling.
 - 4. Control-circuit conductors.
 - 5. Fire alarm wire and cable.
 - 6. Identification products.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. 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.
- E. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- F. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

- a. Nominal OD.
- b. Minimum bending radius.
- c. Maximum pulling tension.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.6 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.

1.7 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 loss test set.
 2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
 3. Test each pair of UTP cable for open and short circuits.

1.8 FIELD CONDITIONS

- A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
 1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
- B. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial 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.

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 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

2.3 UTP CABLE

- A. UTP cable shall comply with Division 27 Specifications, specifically Communications Backbone Cable and Communications Horizontal Cable.

2.4 UTP CABLE HARDWARE

- A. UTP Cable hardware shall comply with Division 27 Specifications, specifically Communications Backbone Cable and Communications Horizontal Cable

2.5 OPTICAL FIBER CABLE

- A. Optical fiber cable shall comply with Division 27 Specifications, specifically Communications Backbone Cable and Communications Horizontal Cable

2.6 OPTICAL FIBER CABLE HARDWARE

- A. Optical fiber hardware shall comply with Division 27 Specifications, specifically Communications Backbone Cable and Communications Horizontal Cable.

2.7 RS-232 CABLE

- A. Standard Cable: NFPA 70, Type CM.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Polypropylene insulation.

3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.8 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 2 pairs, 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, Flame Test.

2.9 LOW-VOLTAGE CONTROL CABLE

A. 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.

B. 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.

2.10 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway Type XHHN, complying with UL 44, in raceway.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

2.11 FIRE ALARM WIRE AND CABLE

- 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. Comtran Corporation.
 2. Draka Cableteq USA.
 3. Genesis Cable Products; Honeywell International, Inc.
 4. Rockbestos-Suprenant Cable Corp.
 5. West Penn Wire.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG or 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 2-hour rating.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 2. Line-Voltage Circuits: No. 12 AWG, minimum.
 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, and complying with requirements in UL 2196 for a 2-hour rating.

2.12 IDENTIFICATION PRODUCTS

- 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. Brady Worldwide, Inc.
 - 2. HellermannTyton North America.
 - 3. Kroy LLC.
 - 4. Panduit Corp..
- B. Comply with 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 260553 "Identification for Electrical Systems."

2.13 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.
- D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.
- E. 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.
- F. Cable will be considered defective if it does not pass tests and inspections.
- G. 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 (21 mm). Control and data transmission wiring shall not share conduit 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."
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring within Enclosures:
1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 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 that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to 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.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. General Requirements for Cabling:
1. Comply with TIA/EIA-568-B.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.
 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

- D. UTP Cable Installation: Install using techniques, practices, and methods that are consistent with Division 27 that ensure performance of completed and linked signal paths, end to end.
- E. Outdoor Coaxial Cable Installation:
 - 1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
 - 2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
- F. 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 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
 - 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- 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. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (300 mm) in diameter below each feed point.
- H. Separation from EMI Sources:
 - 1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
 - 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
- C. Wiring Method:
 1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 2. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
 3. Signaling Line Circuits: Power-limited fire alarm cables **shall not** be installed in the same cable or raceway as signaling line circuits.
- D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different

colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

- G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
- H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 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.

3.6 CONNECTIONS

- A. Comply with requirements in Section 281643 "Perimeter Security Systems" for connecting, terminating, and identifying wires and cables.
- B. Comply with requirements in Section 281600 "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
- C. Comply with requirements in Section 281300 "Access Control" for connecting, terminating, and identifying wires and cables.
- D. Comply with requirements in Section 282300 "Video Surveillance" for connecting, terminating, and identifying wires and cables.
- E. Comply with requirements in Division 28 "PLC Electronic Detention Monitoring and Control Systems" for connecting, terminating, and identifying wires and cables.
- F. Comply with requirements in Division 28 "Digital, Addressable Fire-Alarm System or "Zoned (DC Loop) Fire-Alarm System" for connecting, terminating, and identifying wires and cables.
- G. Comply with requirements in Division 28 "Refrigerant Detection and Alarm" for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

- A. Comply with requirements in Division 07 "Penetration Firestopping."

- B. Comply with TIA-569-B, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

- A. For communications wiring, comply with J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Division 26 "Grounding and Bonding for Electrical Systems."

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. 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/EIA-568-B.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 4. Optical Fiber Cable Tests:

- a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.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-A, 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/EIA-568-B.1.
5. Coaxial Cable Tests: Comply with requirements in Section 274133 "Master Antenna Television System."
- D. 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.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 280513

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.

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.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 CONDUCTORS

- 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. Harger Lightning and Grounding.
 - 2. Panduit Corp.
 - 3. Tyco Electronics Corp.
- 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: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

- A. 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.
- B. 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. Burndy; Part of Hubbell Electrical Systems.
 2. Chatsworth Products, Inc.
 3. Harger Lightning and Grounding.
 4. Panduit Corp.
 5. Tyco Electronics Corp..
- 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 compression or exothermic-type mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.
- 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 requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.

3. Panduit Corp..
- B. Grounding Busbars: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, unless otherwise noted and length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.
 1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
- 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 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 (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm long, with) stainless-steel or copper-plated hardware for attachment to the rack.

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, minimum:
 - a. Grounding bar in an electrical power panelboard if located in the same room or space as the signal ground.
 - b. Telecommunications grounding busbar.

- C. Comply with NECA 1.

3.2 APPLICATION

- A. Conductors: Install solid conductor for No. 6 AWG and smaller and stranded conductors for No. 4 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 (900-mm) 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-B.1 and TIA/EIA-568-B.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.

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SCHEMATIC DESIGN

END OF SECTION 280526

SECTION 280528 - PATHWAYS 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. Metal conduits, tubing, and fittings.
2. Nonmetallic conduits, tubing, and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Surface pathways.
7. Boxes, enclosures, and cabinets.
8. Handholes and boxes for exterior underground cabling.

- B. Related Requirements:

1. Division 26 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Division 26 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
3. Division 27 "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: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. 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."

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways nonmetallic wireways and surface pathways and for each color and texture specified, 12 inches (300 mm) long.

1.5 INFORMATIONAL SUBMITTALS

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

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

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 METAL CONDUITS, TUBING, 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. Alpha Wire Company.
 4. Anamet Electrical, Inc.
 5. Electri-Flex Company.
 6. O-Z/Gedney; a brand of EGS Electrical Group.
 7. Picoma Industries; Subsidiary of Mueller Water Products, Inc.
 8. Republic Conduit.
 9. Robroy Industries
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company; a division of John Maneely 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. 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 or IMC.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. FMC: Comply with UL 1; zinc-coated steel or aluminum.
- I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- J. 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 or compression.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

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

2.2 NONMETALLIC CONDUITS, TUBING, 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. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Arnco Corporation.
 - 5. CANTEX Inc.
 - 6. CertainTeed Corp.
 - 7. Condux International, Inc.
 - 8. Electri-Flex Company.
 - 9. Kraloy.
 - 10. Lamson & Sessions; Carlon Electrical Products.
 - 11. Niedax-Kleinhuis USA, Inc.
 - 12. RACO; a Hubbell Company.
 - 13. Thomas & Betts Corporation.
- 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-B.
- 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. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- L. Solvent cements and adhesive primers 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."

2.3 METAL 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. Cooper B-Line, Inc.
 - 2. Hoffman; a Pentair company.
 - 3. Mono-Systems, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be NEMA 4X and 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. 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: Flanged-and-gasketed type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

- 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. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. Hoffman; a Pentair company.
 - 6. Hubbell Incorporated; Killark Division.
 - 7. Lamson & Sessions; Carlon Electrical Products.
 - 8. Milbank Manufacturing Co.
 - 9. Molex, Woodhead Brand
 - 10. Mono-Systems, Inc.
 - 11. O-Z/Gedney; a brand of EGS Electrical Group.
 - 12. RACO; a Hubbell Company.
 - 13. Robroy Industries.
 - 14. Spring City Electrical Manufacturing Company.

15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. 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.

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

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

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

F. Gangable boxes are prohibited.

G. Cabinets:

1. NEMA 250, Type 1 indoors and NEMA 4X outdoors and in unconditioned space, 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.

2.5 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with TIA-569-B.

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

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

- b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
- 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, "COMMUNICATIONS."
 - 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - 8. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC IMC.
 - 2. Concealed Conduit, Aboveground: GRC IMC.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC, 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 4X.
- 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 or IMC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 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 or IMC.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: 3/4-inch (21-mm) trade size. Minimum size for optical-fiber cables is 1 inch (27 mm).
- 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 or compression, steel fittings. 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 (49 deg C).

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B 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 (150 mm) 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 (300 mm) 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 (300 mm) of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 2 inches (50 mm) 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 or IMC 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 (53-mm) 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 (90-kg) tensile strength. Leave at least 12 inches (300 mm) 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 (50-mm) radius control at bend points.
 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
 2. 1-Inch (27-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- T. 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.
- U. 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.
- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- W. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT 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.
 - d. Attics: 135 deg F (75 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 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.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements.
- 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.
- 3.3 INSTALLATION OF UNDERGROUND CONDUIT
- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.

2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- E. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage 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. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, 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."

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 (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM 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 (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

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

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

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: 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 requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Presealed Systems..

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 (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance..
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) 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 cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow Coaxial-Cable Connectors for CCTV and SSTV: Type BNC, 75 ohms, compressions, quad shield, weather-proof where installed outdoor or in non-environmentally controlled spaces
- H. 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

SECTION 281300 - ACCESS CONTROL

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 central-control station.
 - 2. Security access networked workstation(s).
 - 3. Security access operating system and application software.
 - 4. Security access controllers connected to high-speed electronic-data transmission network.
 - 5. Network connecting all access control controllers, control station, and workstations.
 - 6. Security access control devices.
 - 7. Connection wiring between access controller(s) and access control devices.

1.3 DEFINITIONS

- A. CCTV: Closed-circuit television.
- B. CPU: Central processing unit.
- C. Credential: Data assigned to an entity and used to identify that entity.
- D. dpi: Dots per inch.
- E. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- F. GFI: Ground fault interrupter.
- G. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- H. I/O: Input/Output.
- I. LAN: Local area network.
- J. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- K. PC: Personal computer. Applies to the central station, workstations, and file servers.

- L. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
- M. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
- N. RAS: Remote access services.
- O. RF: Radio frequency.
- P. ROM: Read-only memory. ROM data are maintained through losses of power.
- Q. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- R. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- S. UPS: Uninterruptible power supply.
- T. USB: Universal serial bus.
- U. WAN: Wide area network.
- V. WAV: The digital audio format used in Microsoft Windows.
- W. WMP: Windows media player.
- X. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- Y. Windows: Operating system by Microsoft Corporation.
- Z. Workstation: A PC with software that is configured for specific, limited security-system functions.
- AA. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 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. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
 - D. Other Action Submittals:
 - 1. Project planning documents as specified in Part 3.
- 1.5 INFORMATIONAL SUBMITTALS
- A. Field quality-control reports.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in division 01--"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.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Alarm Printer Black/Red Ribbons: Package of 12.
 - 2. Laser Printers: Three toner cassettes and one replacement drum unit.
 - 3. Credential card blanks, ready for printing. Include 250 credential cards for future use.
 - 4. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.
- 1.8 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.

1.9 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 (10 and 30 deg C), 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.

1.10 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 (16 to 30 deg C) 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 (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 3. Indoor, Uncontrolled Environment: NEMA 250, Type 4X 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 (minus 18 to plus 50 deg C) 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 (minus 34 to plus 50 deg C) 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 (137 km/h).
 - 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 requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Bosch Security Systems, Inc.
 2. General Electric Company; GE Security, Inc.
 3. HES; an ASSA ABLOY Group company.
 4. JCI, Software House.
 5. Keyscan.
 6. Matrix Systems, Inc.
 7. S2.
 8. Software House, Tyco
 9. TAC; Andover Continuum Brand..

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 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 and WAN using 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.
 3. Dial-up and cable modem connection using a standard cable or dial-up telephone line.

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. Each Location shall have its own database and history in the central station.
 3. Locations may be combined to share a common database.
- D. 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.
- E. 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.
- F. 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.
- G. System Response to Alarms:
1. Field device network shall provide a system end-to-end response time of [one] second(s) 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.

- H. 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.
- I. Error Detection:
 - 1. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
 - 2. Interactive or product error-detection codes alone will not be acceptable.
 - 3. A message shall be in error if one bit is received incorrectly.
 - 4. Retransmit messages with detected errors.
 - 5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
 - 6. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
 - 7. Monitor the frequency of data transmission failure for display and logging.
- J. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- K. 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 or Linux 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, 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/or a selected workstation 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, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.

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. Up to 64 controllers connected to TIA 485-A communications loop. 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 TIA 485-A communications loop of each Location.
 - b. Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.
 - c. Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.
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.
 - c. Dial-up or cable modems for connections to Locations.
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. Dial-up Modem or Cable Modem PC-to-Controller Communications:

1. Communication software on the PC shall supervise the PC-to-controller communications link during dial-up modem connect times.
2. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
3. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
4. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the PC.
5. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host PC will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host PC.
6. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.

7. Alarms shall be reported immediately.
8. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.

I. Controller-to-Controller Communications:

1. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
2. TIA 485-A communications signal shall be regenerated at each controller.

J. 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.
3. Software shall provide for setting downloads via dial-up connection to once per 24-hour period, with time selected by the operator.
4. Software shall provide for setting delays of database downloads for dial-up connections. Delays change the download from immediately to a delay ranging from one to 999 minutes.

K. 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.

L. 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. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
- 3. 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.
- 4. The password shall not be displayed or printed.
- 5. 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.

M. 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 second(s).
- 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) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
 - 2) Arm or disarm each monitored input up to four times a day through time-zone programming.
 - 3) Enable or disable readers or keypads up to two times a day through time-zone programming.
 - 4) 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.

N. Alarms:

- 1. System Setup:
 - a. Assign manual and automatic responses to incoming-point status change or alarms.
 - b. 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.
 - c. Sixty-character message field for each alarm.
 - d. 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 access point, zone, and sensor.

- e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
 - f. Allow 25 secondary messages with a field of four lines of 60 characters each.
 - g. Store the most recent 1000 alarms for recall by the operator using the report generator.
 2. Software Tamper:
 - a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
 - b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
 - c. Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
 - d. Allow only acknowledgment of software tamper alarms.
 3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
 4. 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.
 5. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
 6. 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.
 7. 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 TIA 232-F ASCII interface.
 8. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
 9. Camera Control: Provides operator ability to select and control cameras from graphic maps.
- O. 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.
- P. 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. GREEN: 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. 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.

- g. 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.
- Q. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
 - 1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.
- R. 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. Emergency Muster Report: One-click operation on toolbar launches report.
 - b. 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.
- S. 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.
- T. 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. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
7. 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.

U. Time and Attendance:

1. Time and attendance reporting shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
2. Shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
3. System software setup shall allow designation of selected access-control readers as time and attendance hardware to gather the clock-in and clock-out times of the users at these readers.
 - a. Reports shall show in and out times for each day, total time in for each day, and a total time in for period specified by the user.
 - b. Allow the operator to view and print the reports, or save the reports to a file.
 - c. Alphabetically sort reports on the person's last name, by Location or location group. Include all credential holders or optionally select individual credential holders for the report.

V. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.

W. 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 ASCII 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.

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 3.5-inch floppy disk, Zip and Jaz 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. Require passwords to be case sensitive.
 3. Passwords shall not be displayed when entered.
 4. 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.
 5. 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.
 6. 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.
- 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.

O. Code Tracing:

1. System shall perform code tracing selectable by cardholder and by reader.
2. Any code may be designated as a "traced code" with no limit to how many codes can be traced.
3. Any reader may be designated as a "trace reader" with no limit to which or how many readers can be used for code tracing.
4. When a traced code is used at a trace reader, the access-granted message that usually appears on the monitor window of the central station shall be highlighted with a different color than regular messages. A short singular beep shall occur at the same time the highlighted message is displayed on the window.
5. The traced cardholder image (if image exists) shall appear on workstations when used at a trace reader.

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 HARDWARE

- A. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 64 bytes or larger; the CPU operating speed shall be at least 3 GHz.
 - 1. Memory: 32 GB of usable installed memory.
 - 2. Power Supply: Minimum capacity of 650 W.
 - 3. Real-Time Clock:
 - a. Accuracy: Plus or minus one minute per month.
 - b. Time-Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
 - c. Clock shall function for one year without power.
 - d. Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
 - 4. Serial Ports: Provide two TIA 232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
 - 5. Parallel Port: An enhanced parallel port.
 - 6. LAN Adapter Card: 1000 Mbps PCI bus, internal network interface card.
 - 7. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
 - 8. Color Monitor: (if used solely for the Security Access System, i.e. not shared with the Closed Circuit Television system) Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch to match monitor resolution. The video card shall support at least 256 colors at a full screen resolution at a minimum refresh rate of 70 Hz.
 - 9. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
 - 10. Mouse: Standard, compatible with the installed software.
 - 11. 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.
- 12. Disk storage shall include the following, each with appropriate controller:
 - a. Minimum 500 GB hard disk, maximum average access time of 10 ms.
- 13. Audible Alarm: Manufacturer's standard.
- 14. Report Printer:
 - a. Connected to the central station and designated workstations.
 - b. Laser printer with minimum resolution of 600 dpi.
 - c. RAM: 2 MB, minimum.
 - d. Printing Speed: Minimum 12 pages per minute.
 - e. Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
- 15. Interface: Bidirectional parallel, and universal serial bus.
- 16. LAN Adapter Card: 100 Mbps (minimum) internal network interface card.
- B. Redundant Central Computer: One identical redundant central computer, connected in a hot standby, peer configuration. This computer shall automatically maintain its own copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real time. If central computer fails, redundant computer shall assume control immediately and automatically.
- C. UPS: Self-contained; complying with requirements and Division 26 requirements.
 - 1. Size: Provide a minimum of six hours of operation of the central-station equipment, including two hours of alarm printer operation.
 - 2. Batteries: Sealed, valve regulated, recombinant, lead calcium.
 - 3. Accessories:
 - a. Transient voltage suppression.
 - b. Input-harmonics reduction.
 - c. Rectifier/charger.
 - d. Battery disconnect device.
 - e. Static bypass transfer switch.
 - f. Internal maintenance bypass/isolation switch.
 - g. External maintenance bypass/isolation switch.
 - h. Output isolation transformer.
 - i. Remote UPS monitoring.
 - j. Battery monitoring.
 - k. Remote battery monitoring.
 - l. .

2.8 STANDARD WORKSTATION HARDWARE

- A. Workstation shall consist of a standard unmodified PC with accessories and peripherals that configure the workstation for a specific duty.

- B. Workstation Computer: Standard unmodified PC of modular design. The CPU word size shall be 64 bytes or larger; the CPU operating speed shall be at least 6 GHz.
1. Memory: 32 GB of usable installed memory.
 2. Power Supply: Minimum capacity of 650 W.
 3. Real-Time Clock:
 - a. Accuracy: Plus or minus one minute per month.
 - b. Time-Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
 - c. Provide automatic time correction once every 24 hours by synchronizing clock with the central station.
 4. Serial Ports: Provide two TIA 232-F USB serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
 5. Parallel Port: An enhanced parallel port.
 6. Sound Card: For playback and recording of digital WMP sound files that are associated with audible warning and alarm functions.
 7. Color Monitor: Not less than 24 inch, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch to match resolution. The video card shall support at least 256 colors at a resolution to match the monitor at a minimum refresh rate of 70 Hz.
 8. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
 9. Mouse: Standard, compatible with the installed software. Minimum resolution shall be 400 dpi.
- C. UPS: Self-contained, complying with requirements in Section 263353 "Static Uninterruptible Power Supply."
1. Size: Provide a minimum of [six] hours of operation of the central-station equipment, including two hours of alarm printer operation.
 2. Batteries: Sealed, valve regulated, recombinant, lead calcium.
 3. Accessories:
 - a. Transient voltage suppression.
 - b. Input-harmonics reduction.
 - c. Rectifier/charger.
 - d. Battery disconnect device.
 - e. Static bypass transfer switch.
 - f. Internal maintenance bypass/isolation switch.
 - g. External maintenance bypass/isolation switch.
 - h. Output isolation transformer.
 - i. Remote UPS monitoring.
 - j. Battery monitoring.
 - k. UPS operation monitoring.
 - l. Abnormal operation. Visible and audible indication.
 - m. Remote battery monitoring..

2.9 FIXED MAP DISPLAY

- A. A fixed map display shall show layout of the protected facilities. Zones corresponding to those monitored by the system shall be highlighted on the display. Status of each zone shall be displayed using digital displays as required within each designated zone. A digital display test switch shall be provided on the map display.

2.10 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, with dc line supervision on each of its alarm inputs.
 - 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 by monitoring for abnormal open, grounded, or shorted conditions using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 10 percent or more for longer than 500 ms.
 - 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 and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
 - 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, alarm sounds.
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. Store up to 1000 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. Backup Battery: Premium, valve-regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full one-year warranty and a pro rata 9-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.
 - b. Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. 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.
 - c. Backup Power-Supply Capacity: 90 minutes of battery supply. Submit battery and charger calculations.
 - d. 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.

2.11 SECONDARY ALARM ANNUNCIATOR

- A. Secondary Alarm Annunciation Site: A workstation with limited I/O capacity, consisting of a secondary alarm annunciation workstation to allow the operator to duplicate functions of the main operator interface and to show system status changes.

2.12 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. Stripe Swipe Readers: Bidirectional, reading cards swiped in both directions, powered by the controller. Reader shall be set up for ABA Track.
 - 1. ABA Track: Magnetic stripe that is encoded on track 2, at 75-bpi density in binary-coded decimal format; for example, 5-bit, 16-character set.
 - 2. Readers for outdoors shall be in a polymeric plastic enclosure with all electronics potted in plastic. Rated for operation in ambient conditions of minus 40 to plus 160 deg F (minus 40 to plus 70 deg C) in a humidity range of 10 to 90 percent.
- F. Touch-Plate and 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 6 inches (150 mm) from the reader.
- 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 ascending ASCII-code ordinal sequence.

3. Communication protocol shall be compatible with the local processor.
- H. Scramble 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.
- I. 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.
- J. 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.
- K. Keypad Power:
1. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
- L. Keypad Mounting Method:
1. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
- M. Keypad Duress Codes:
1. Keypads shall provide a means for users to indicate a duress situation by entering a special code.
- N. Keypad and Wiegand-Swipe-Reader Combination: Designed to require an entry on the keypad before presenting the credential card.
1. Keypad: Allow the entry of four numeric digits that are associated with a specific credential. Keypads shall contain an integral alphanumeric/special symbol keyboard with symbols arranged in ascending ASCII-code ordinal sequence. Keypad display or 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.

2. Wiegand Swipe Reader: Provide reader as specified above.
- O. Communication Protocol: Compatible with local processor.
- P. Touch-Plate and Contactless Card 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.
- Q. 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.
- R. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches (54 by 86 mm). 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.
- S. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
- T. 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 or phosphorous ink as a security enhancement.
 4. Furnish equipment for on-site assembly and lamination of credential cards.

2.13 ENROLLMENT CENTER

- 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. Applied Wireless Identifications Group, Inc.
 2. Autostar Technology Pte Ltd.
 3. Digital Monitoring Products.
 4. IDenticard Systems.
 5. ISONAS, Inc.
 6. Ultra Electronics.
- B. Equipment for enrolling personnel into, and removing personnel from, system database, using a dedicated workstation PC.
 1. Include equipment to enroll selected biometric credentials.
- C. 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.
 3. Enrollment-station records printer shall meet requirements of the report printer.

D. 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.

E. Accessories:

1. Steel desk-type console, swivel chair on casters, and equipment racks.
2. Console and Equipment Racks: Comply with EIA/ECA-310-E.
3. Equipment, with the exception of the printers, shall be rack mounted in the console and equipment racks.
- 4.

F. System Capacity: Number of badges shall be limited only by hard disk space. Badge templates and images shall be in color, supporting the maximum color capability of Microsoft Windows.

G. 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.

H. Photo Imaging: Integral to security access.

1. Import images from bitmap file formats, digital cameras, TWAIN 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.
- I. 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.
- J. 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: 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. Card Size and Dimensional Stability: Standard size, 2-1/8 by 3-3/8 inches (54 by 86 mm); dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
 - b. Card Material: Abrasion resistant, nonflammable, and nontoxic; and impervious to solar radiation and effects of ultraviolet light.
 - c. 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 or phosphorous ink as a security enhancement.
 - 2) Furnish equipment for on-site assembly and lamination of credential cards.
 - d. Card Durability and Maintainability: Designed and constructed to yield a useful lifetime of at least five years or 5000 insertions or swipes, whichever results in a longer period of time. Allow credential cards to be cleaned by wiping with a sponge or cloth wetted with soap and water.
- K. Card-Making Equipment: Consisting of a workstation, video camera, video-imaging equipment, and a printer.
1. Camera: NTSC color standard, 2 mega pixel minimum, and automatic white balance with full rated output under illumination of 0.5 fc (5 lx).
 2. Video Imaging: Live-image capture software and hardware and a digital signature capture pad.
 3. Standard workstation, modified as follows:
 - a. Redundant workstation is not required.
 - b. Printer is not required.
 - c. UPS is not required.
 - d. Sound card is not required.

4. Printer: Dye-sublimation resin thermal transfer, 600 dpi resolution, 16.7 million colors, accepting cards ranging in size from 2.1 by 3 inches to 2.6 by 3.7 inches (53 by 76 mm to 66 by 94 mm) and having card thickness ranging from 0.020 to 0.060 inch (0.5 to 1.5 mm). Printer shall have options for encoding magnetic stripe using tracks 1, 2, and 3. Throughput shall be not less than 60 seconds per card.

2.14 PUSH-BUTTON SWITCHES

- 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. Securitron Magnalock Corporation; an ASSA ABLOY Group company.
- B. Push-Button Switches: Momentary-contact back-lighted push buttons with stainless-steel switch enclosures.
- C. Electrical Ratings:
 1. Minimum continuous current rating of 10 A at 120-V ac or 5 A at 240-V ac.
 2. Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.
- D. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
- E. Enclosures shall additionally be suitable for installation in the following locations:
 1. Indoors, controlled environment.
 2. Indoors, uncontrolled environment.
 3. Outdoors.
- F. Power: Push-button switches shall be powered from their associated controller, using dc control.

2.15 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local 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: Use end-of-line resistors to provide power-line supervision. 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."

2.16 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.
5. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).

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 flash ROM technology 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.

2.17 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 RS-485 or 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 eight hours 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. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
4. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
5. Batteries shall be sealed, non-outgassing type.
6. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
7. 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 RS-485 or TCP/IP as a minimum.
25. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

2.18 TIA 232-F ASCII INTERFACE SPECIFICATIONS

- A. ASCII interface shall allow TIA 232-F connections to be made between the control station operating as the host PC and any equipment that will accept TIA 232-F ASCII command strings, such as CCTV switches, intercoms, and paging systems.
 - 1. Alarm inputs in system shall allow for individual programming to output up to four unique ASCII character strings through two different COM ports on the host PC.
 - 2. Inputs shall have the ability to be defined to transmit a unique ASCII string for alarm and one for restore through one COM port, and a unique ASCII string for a nonalarm, abnormal condition and one for a normal condition through the same or different COM port.
 - 3. Predefined ASCII character strings shall have the ability to be up to 420 characters long with full use of all the ASCII control characters, such as return or line feed. Character strings shall be defined in the system database and then assigned to the appropriate inputs.
 - 4. COM ports of the host PC used to interface with external equipment shall be defined in the setup portion of the software. COM port's baud rate, word length, stop bits, and parity shall be definable in the software to match that of the external equipment.
- B. Pager-System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
 - 1. TIA 232-F output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to the paging system. This interface shall support both numeric and alphanumeric pagers.
- C. Alarm-System Interface:
 - 1. TIA 232-F output shall be capable of transmitting alarms from other monitoring and alarm systems to central-station automation software.
 - 2. Alternatively, alarms that are received by this access-control system are to be transferred to the alarm automation system as if they were sent through a digital alarm receiver.
 - a. System shall be able to transmit an individual message from any alarm input to a burglar-alarm automation monitoring system.
 - b. System shall be able to append to each message a predefined set of character strings as a prefix and a suffix.

2.19 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.

2.20 REAL-TIME GUARD TOUR

- A. Guard tour module shall provide the ability to plan, track, and route tours. Module shall input an alarm during tour if guard fails to make a station. Tours can be programmed for sequential or random tour-station order.
 - 1. Guard tour setup shall define specific routes or tours for the guard to take, with time restrictions in which to reach every predefined tour station.
 - 2. Guard tour activity shall be automatically logged to the central-station PC's hard drive.
 - 3. If the guard is early or late to a tour station, a unique alarm per station shall appear at the central station to indicate the time and station.
 - 4. Guard tour setup shall allow the tours to be executed sequentially or in a random order with an overall time limit set for the entire tour instead of individual times for each tour station.
 - 5. Setup shall allow recording of predefined responses that will display for the operator at the control station should a "Failed to Check In" alarm occur.
- B. Guard tour module shall allow proprietary direct-connected systems to use security access-control hardware to perform guard tour management in real time.
- C. A tour station is a physical location where a guard shall go and perform an action indicating that he or she has arrived. This action, performed at the tour station, shall be one of 13 different events with any combination of station types within the same tour. An event at a tour station shall be one of the following types:
 - 1. Access Granted.
 - 2. Access Denied Code.
 - 3. Access Denied Card plus PIN.
 - 4. Access Denied Time Zone.
 - 5. Access Denied Level.
 - 6. Access Denied Facility.
 - 7. Access Denied Code Timer.
 - 8. Access Denied Anti-Passback.
 - 9. Access Granted Passback Violation.
 - 10. Alarm.
 - 11. Restored.
 - 12. Input Normal.
 - 13. Input Abnormal.
- D. Guard tour and other system features shall operate simultaneously with no interference.

- E. Guard Tour Module Capacity: 999 possible guard tour definitions with each tour having up to 99 tour stations. System shall allow all 999 tours to be running at the same time.

2.21 VIDEO AND CAMERA CONTROL

- A. Control station or designated workstation displays live video from a CCTV source.
 - 1. Control Buttons: On the display window, with separate control buttons to represent Left, Right, Up, Down, Zoom In, Zoom Out, Scan, and a minimum of two custom-command auxiliary controls.
 - 2. Provide at least seven icons to represent different types of cameras, with ability to import custom icons. Provide option for display of icons on graphic maps to represent their physical location.
 - 3. Provide the alarm-handling window with a command button that will display the camera associated with the alarm point.
- B. Display mouse-selectable icons representing each camera source, to select source to be displayed. For CCTV sources that are connected to a video switcher, control station shall automatically send control commands through a COM port to display the requested camera when the camera icon is selected.
- C. Allow cameras with preset positioning to be defined by displaying a different icon for each of the presets. Provide control with Next and Previous buttons to allow operator to cycle quickly through the preset positions.

2.22 CABLES

- A. General Cable Requirements: Comply with requirements in Division 28 "Conductors and Cables for Electronic Safety and Security" and as recommended by system manufacturer for integration requirement.
- B. PVC-Jacketed, TIA 232-F Cables:
 - 1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; PVC jacket.
 - 2. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 3. NFPA 70, Type CM.
 - 4. Flame Resistance: UL 1581 vertical tray.
- C. Plenum-Type, TIA 232-F Cables:
 - 1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; plastic jacket.
 - 2. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 3. NFPA 70, Type CMP.
 - 4. Flame Resistance: NFPA 262 flame test.
- D. PVC-Jacketed, TIA 485-A Cables: Two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
- E. Plenum-Type, TIA 485-A Cables:

1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
 2. NFPA 70, Type CMP.
 3. Flame Resistance: NFPA 262 flame test.
- F. Multiconductor, PVC, Reader and Wiegand Keypad Cables:
1. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CMG.
 3. Flame Resistance: UL 1581 vertical tray.
 4. For TIA 232-F applications.
- G. Paired, PVC, Reader and Wiegand Keypad Cables:
1. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CM.
 3. Flame Resistance: UL 1581 vertical tray.
- H. Paired, PVC, Reader and Wiegand Keypad Cables:
1. Three pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
 2. NFPA 70, Type CM.
 3. Flame Resistance: UL 1581 vertical tray.
- I. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:
1. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 2. NFPA 70, Type CMP.
 3. Flame Resistance: NFPA 262 flame test.
- J. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:
1. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 2. NFPA 70, Type CMP.
 3. Flame Resistance: NFPA 262 flame test.
- K. Paired, Lock Cables:
1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
 2. NFPA 70, Type CMG.
 3. Flame Resistance: UL 1581 vertical tray.

L. Paired, Plenum-Type, Lock Cables:

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

M. Paired, Lock Cables:

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.

N. Paired, Plenum-Type, Lock Cables:

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

O. Paired, Input Cables:

1. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, overall aluminum-foil/polyester-tape shield with No. 22 AWG, stranded (7x30) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CMR.
3. Flame Resistance: UL 1666 riser flame test.

P. Paired, Plenum-Type, Input Cables:

1. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum-foil/polyester-tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

Q. Paired, AC Transformer Cables:

1. One pair, twisted, No. 18 AWG, stranded (7x26) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMG.

R. Paired, Plenum-Type, AC Transformer Cables:

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

S. Elevator Travel Cables:

1. Steel center core with shielded, twisted pairs, No. 20 AWG conductor size.

2. Steel center core support shall be preformed, flexible, low-torsion, zinc-coated, steel wire rope; insulated with 60 deg C flame-resistant PVC and covered with a nylon or cotton braid.
3. Shielded pairs shall be insulated copper conductors; color-coded, insulated with 60 deg C flame-resistant PVC; each pair shielded with bare copper braid for 85 percent coverage.
4. Electrical grade, dry jute filler.
5. Helically wound synthetic fiber binder.
6. Rayon or cotton braid applied with 95 percent coverage.
7. 60 deg C PVC jacket specifically compounded for flexibility and abrasion resistance; and complying with UL VW-1 and CSA FT1 flame rated.

T. LAN Cabling:

1. Comply with requirements in Division 28 "Conductors and Cables for Electronic Safety and Security."
2. NFPA 262.

2.23 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

2.24 CABLE AND ASSET MANAGEMENT SOFTWARE

- 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. Greenlee Textron Inc.; a subsidiary of Textron Inc.
2. Total Wire Software Company, Inc.

- B. Computer-based cable and asset management system, with fully integrated database and graphic capabilities, complying with requirements in TIA/EIA 606-A.

1. Document physical characteristics by recording the network, asset, user, TIA/EIA details, device configurations, and exact connections between equipment and cabling.
 - a. Manage the physical layer of security system.
 - b. List device configurations.
 - c. List and display circuit connections.
 - d. Record firestopping data.
 - e. Record grounding and bonding connections and test data.
2. Information shall be presented in database view, schematic plans, or technical drawings.
 - a. Microsoft Visio Technical Drawing shall be used as drawing and schematic plans software. Drawing symbols, system layout, and design shall comply with SIA/IAPSC AG-01.
3. System shall interface with the following testing and recording devices:
 - a. Direct-upload tests from circuit testing instrument into the PC.
 - b. Direct-download circuit labeling into labeling printer.

- C. Software shall be designed for Windows or Linux operating system of the same version as security access system's central station and workstations and shall be installed on the designated PC, using a hard drive dedicated only to this management function. Hard-drive capacity shall be not less than 300 GB.

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 roughing-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-A, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents 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 Project planning documents and review, adjust, and prepare final setup documents. Use final documents 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 5E rating of components and fiber-optic rating of components, and that ensure Category 6 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-B, "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. TIA 232-F Cabling: Install at a maximum distance of 50 ft. (15 m).
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. (1220 m).
- E. 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. (75 m), and install No. 20 AWG wire if maximum distance is 500 ft. (150 m).
 - 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.
- F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft. (75 m).

- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. (8 m).

3.5 GROUNDING

- A. Comply with Division 26 "Grounding and Bonding for Electrical Systems."
- 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- (6.4-mm-) 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, push buttons, and biometric readers.

3.7 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Division 26 "Identification for Electrical Systems" and with TIA/EIA 606-A.
- 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, Category 5 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 281600 - INTRUSION DETECTION

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. Intrusion detection with communication links to perform monitoring, alarm, and control functions.
 - 2. Integration of other electronic and electrical systems and equipment.
- B. Related Sections:
 - 1. Division 28 "Conductors and Cables for Electronic Safety and Security."
 - 2. Division 28 "Video Surveillance."

1.3 DEFINITIONS

- A. CCTV: Closed-circuit television.
- B. PIR: Passive infrared.
- C. RFI: Radio-frequency interference.
- D. UPS: Uninterruptible power supply.
- E. Control Unit: System component that monitors inputs and controls outputs through various circuits.
- F. 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.
- G. 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.
- H. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
- I. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes.
- J. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

- K. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
- L. 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.

1.4 ACTION SUBMITTALS

- A. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
 - 1. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers, networks and control interface devices and media to be used. Describe characteristics of network and other data communication lines.
 - a. Indicate methods used to achieve systems integration.
 - b. Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
 - c. Describe characteristics of network and other data communication lines.
 - d. Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.
 - 2. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
 - 3. UPS: Sizing calculations.
 - 4. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
 - 5. Master Control-Unit Console Layout: Show required artwork and device identification.
 - 6. Device Address List: Coordinate with final system programming.
 - 7. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
 - 8. Details of surge-protection devices and their installation.
 - 9. Sensor detection patterns and adjustment ranges.
- C. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
- D. Samples for Initial Selection: For units with factory-applied color finishes.

- E. Samples for Verification: For each type of exposed finish required.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, intrusion detection systems integrator, and testing agency.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.
- D. Other Information Submittals:
 - 1. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
 - 2. Examination reports documenting inspections of substrates, areas, and conditions.
 - 3. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For intrusion detection 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. Data for each type of product, including features and operating sequences, both automatic and manual.
 - 2. Master control-unit hardware and software data.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.
 - 2. Fuses: Three of each kind and size.
 - 3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
 - 4. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
 - 2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

- B. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- C. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- D. 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.
- E. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.
- F. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.
- G. Comply with NFPA 70.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Altitude: Sea level to 2000 feet (610 m).
 - 2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
 - 3. Interior, Controlled Environment: System components, except master control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 4. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambients of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 - 5. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h).
 - 6. 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 or flyings shall be rated, listed, and installed according to NFPA 70.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Description: Hard-wired on multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.
- B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 - 1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
 - 2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
 - 3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.
- C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.
- D. System Control: Master control unit shall directly monitor intrusion detection devices and connecting wiring in a multiplexed distributed control system or as part of a network.
- E. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
- F. Operator Commands:
 - 1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
 - 2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 - 3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 - 4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 - 5. Protected Zone Test: Initiate operational test of a specific protected zone.
 - 6. System Test: Initiate system-wide operational test.
 - 7. Print reports.
- G. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
- H. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
 - 1. Switch selected lights.
 - 2. Shift elevator control to a different mode.
 - 3. Open a signal path between certain intercommunication stations.
 - 4. Shift sound system to "listening mode" and open a signal path to certain system speakers.
 - 5. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.

- I. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
- J. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.
- K. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
- L. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
- M. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.2 SYSTEM COMPONENT REQUIREMENTS

- A. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the following equipment:
 - 1. Door hardware specified in Division 08 "Door Hardware."
 - 2. Door hardware specified in Division 08 "Door Hardware (Descriptive Specification)."
 - 3. Elevators specified in Division 14 "Electric Traction Elevators."
 - 4. Elevators specified in Division 14 "Hydraulic Elevators."
 - 5. Lighting controls specified in Division 26 "Lighting Control Devices."
 - 6. Lighting controls specified in Division 26 "Addressable-Fixture Lighting Controls" and Division 26 "Relay-Based Lighting Controls."
 - 7. Intercom and program systems specified in Division 27 "Intercommunications and Program Systems."
 - 8. Public address and mass notification systems specified in Division 27 "Public Address and Mass Notification Systems."
 - 9. Access control system specified in Division 28 "Access Control."
 - 10. Fire alarm system specified in Division 28 "Fire-Alarm System."
 - 11. Perimeter security system specified in Division 28 "Perimeter Security Systems."
 - 12. Video surveillance system specified in Division 28 "Video Surveillance."
 - 13. Access control system specified in Division 28 "Access Control."
- B. 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 Lines 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 Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.
- C. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
- D. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.
- E. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.
- F. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.
- G. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.
- H. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.
- I. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

- A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
- B. Interior Electronics: NEMA 250, Type 12.
- C. Exterior Electronics: NEMA 250, Type 4X, stainless steel.
- D. Corrosion Resistant: NEMA 250, Type 4X, stainless steel.
- E. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 SECURE AND ACCESS DEVICES

- 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. Bosch Security Systems, Inc.
 2. Corby Industries, Inc.

3. Crow Electronic Engineering, Inc.
4. DAQ Electronics, Inc.
5. Digital Security Controls Ltd.; a business unit of Tyco Safety Products.
6. Edwards Signaling & Security Systems; part of GE Security.
7. Honeywell International Inc.; Honeywell Security.
8. Visonic Inc.

- B. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
- C. Key-Operated Switch: Change protected zone between secure and access conditions.

2.5 DOOR AND WINDOW SWITCHES

- 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. Aleph America Corporation.
 2. General Electric Company; GE Security, Inc.
 3. George Risk Industries.
 4. Honeywell International Inc.; Honeywell Security.
 5. Honeywell International Inc.; Honeywell Video Systems.
 6. Optex Inc.
 7. Potter Electric Signal, LLC.
- B. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity.
- C. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.
- D. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounted magnet and floor-mounted switch unit.
- E. Remote Test: Simulate movement of actuating magnet from master control unit.

2.6 PIR SENSORS

- 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. Aleph America Corporation.
 2. Bosch Security Systems, Inc.
 3. Crow Electronic Engineering, Inc.
 4. Digital Security Controls Ltd.; a business unit of Tyco Safety Products.
 5. General Electric Company; GE Security, Inc.
 6. Honeywell International Inc.; Honeywell Security.
 7. Visonic Inc.
- B. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.

- C. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
1. Wall-Mounted Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.
 2. Ceiling-Mounted Unit Spot-Detection Pattern: Full 360-degree conical.
 3. Ceiling-Mounted Unit Pattern Size: 84-inch (2135-mm) diameter at floor level for units mounted 96 inches (2440 mm) above floor; 18-foot (5.5-m) diameter at floor level for units mounted 25 feet (7.6 m) above floor.
- D. Device Performance:
1. Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across two adjacent segments of detector's field of view.
 2. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.
 3. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

2.7 ACOUSTIC-TYPE, GLASS-BREAK SENSORS

- 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. Crow Electronic Engineering, Inc.
 2. Digital Security Controls Ltd.; a business unit of Tyco Safety Products.
 3. General Electric Company; GE Security, Inc.
 4. Honeywell International Inc.; Honeywell Security.
 5. International Electronics, Inc.
 6. Potter Electric Signal, LLC.
 7. Visonic Inc.
- B. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
- C. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.
1. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a 20-foot (6-m) range.
 2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
 3. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
 4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.8 PIEZOELECTRIC-TYPE, GLASS-BREAK SENSORS

- 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. General Electric Company; GE Security, Inc.
 - 2. Honeywell International Inc.; Honeywell Security.
 - 3. Potter Electric Signal, LLC.
 - 4. Visonic Inc.
- B. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
- C. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.
 - 1. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a 60-inch (1525-mm) radius on a continuous glass pane. Sensor element shall not be larger than 4 sq. in. (25.80 sq. cm).
 - 2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
 - 3. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
 - 4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 - 5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.9 DURESS-ALARM SWITCHES

- 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. General Electric Company; GE Security, Inc.
 - 2. Honeywell International Inc.; Honeywell Security.
 - 3. Visonic Inc.
- B. Description: A switch with a shroud over the activating lever that allows an individual to covertly send a duress signal to master control unit, with no visible or audible indication when activated. Switch shall lock in activated position until reset with a key.
 - 1. Minimum Switch Rating: 50,000 operations.
 - 2. Foot Rail: Foot activated, floor mounting.
 - 3. Push Button: Finger activated, suitable for mounting on horizontal or vertical surface.

2.10 MASTER CONTROL UNIT

- 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. Bosch Security Systems, Inc.
 - 2. DAQ Electronics, Inc.
 - 3. Digital Security Controls, Inc.; a business unit of Tyco Safety Products.
 - 4. General Electric Company; GE Security, Inc.

5. Honeywell International Inc.; Honeywell Security.
 6. Honeywell International Inc.; Honeywell Video Systems.
 7. Visonic Inc.
- B. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 2. Include a real-time clock for time annotation of events on the event recorder and printer.
 3. Addressable initiation devices that communicate device identity and status.
 4. Control circuits for operation of mechanical equipment in response to an alarm.
- C. Construction: Wall mounted, modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
- D. Comply with UL.
- E. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: LCD, two line(s) of 80 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 3. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
 4. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
 5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
 - a. Acknowledge alarm.
 - b. Silence alarm.
 - c. System reset.
 - d. LED test.
 6. Timing Unit: Solid state, programmable, 365 days.
 7. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
 8. Alarm Indication: Audible signal sounds and a plain-language identification of the addressable detector originating the alarm appears on LCD display at master control unit.
 9. Alarm activation sounds a **siren and strobe**.

- F. Protected Zones: Quantity of alarm and supervisory points as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
- G. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
- H. UPS: Comply with Section 263353 "Static Uninterruptible Power Supply." UPS shall be sized to provide a minimum of six hours of master control-unit operation.
- I. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
- J. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
- K. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

2.11 AUDIBLE AND VISUAL ALARM DEVICES

- 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. Alarm Controls Corporation.
 - 2. Cooper Wheelock.
 - 3. Edwards Signaling & Security Systems; part of GE Security.
 - 4. Honeywell International Inc.; Honeywell Security.
 - 5. Potter Electric Signal, LLC.
 - 6.
 - 7.
- B. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from unit.
 - 1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
- C. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
 - 1. Light Output: 115 cd, minimum.
 - 2. Flash Rate: 60 per minute.

2.12 SECURITY FASTENERS

- A. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
- B. Drive System Types: Pinned Torx-Plus, pinned Torx or pinned hex (Allen).
- C. Socket Flat Countersunk Head Fasteners:
 - 1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- D. Socket Button Head Fasteners:
 - 1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 - 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- E. Socket Head Cap Fasteners:
 - 1. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 - 2. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
- F. Protective Coatings for Heat-Treated Alloy Steel:
 - 1. Zinc chromate, ASTM F 1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
 - 2. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

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 intrusion detection.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.

- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

- A. Integrate intrusion detection system with the following systems and equipment:

1. Electronic door hardware.
2. Elevators.
3. Network lighting controls.
4. Intercommunications and program systems.
5. Public address and mass notification systems.
6. Access control.
7. Fire-alarm system.
8. Perimeter security system.
9. Video surveillance.

3.3 SYSTEM INSTALLATION

- A. Comply with UL 681 and NFPA 731.
- B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Security Fasteners: Install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

3.4 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Section 260533 "Raceways and Boxes for Electrical Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Install wiring in metal raceways according to Section 260533 "Raceways and Boxes for Electrical Systems," except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.

- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Wires and Cables:
 - 1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
 - 2. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
 - 3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 280513 "Conductors and Cables for Electronic Safety and Security."
 - 4. Data and Television Signal Transmission Cables: Install according to Section 280513 "Conductors and Cables for Electronic Safety and Security."
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- G. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
- H. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 260553 "Identification for Electrical Systems."
- B. Install instructions frame in a location visible from master control unit.

3.6 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- D. 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.
- E. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."
 - 1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
- F. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
- G. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

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 three visits to Project during other-than-normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 281600

SECTION 282300 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes a video surveillance system consisting of cameras, digital video recorder, data transmission wiring, and a control station with its associated equipment.
- B. Video surveillance system shall be integrated with monitoring and control system(s) specified in
 - 1. Division 28 "Intrusion Detection."
 - 2. Division 28 "Access Control."

1.3 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.
- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. MPEG: Moving picture experts group.
- I. NTSC: National Television System Committee.
- J. PC: Personal computer.
- K. PTZ: Pan-tilt-zoom.
- L. RAID: Redundant array of independent disks.
- M. TCP: Transmission control protocol - connects hosts on the Internet.
- N. UPS: Uninterruptible power supply.
- O. WAN: Wide area network.

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. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
 - 3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
 - 4. UPS: Sizing calculations.
 - 5. Wiring Diagrams: For power, signal, and control wiring.
- C. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.6 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in

emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.
- D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: 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 temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
 2. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
 3. Interior, Uncontrolled Environment: System components installed in non- temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of Insert temperature range dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 4X enclosures.
 4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h). Use NEMA 250, Type 4X enclosures.
 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: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X enclosures.
 7. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

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: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.
- B. 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's 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.
- C. 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.

2.2 STANDARD CAMERAS

- 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. AXIS Inc.
 2. Bosch Security Systems, Inc.
 3. JVC Americas Corp.; JVC Professional products.
 4. Panasonic Corporation of North America; Panasonic Security Systems.
 5. Pelco.
 6. Samsung Opto-Electronics.
 7. SANYO North America Corporation.
 8. Toshiba Corporation; Surveillance products.
 9. Vicon Industries, Inc.
- B. Color Camera:
 1. Comply with UL 639.
 2. Pickup Device: CCD minimum 2 Mega Pixels.
 3. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
 4. With AGC, manually selectable on or off.
 5. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of 5 lux at f1.4, with camera AGC off.
 6. Manually selectable modes for backlight compensation or normal lighting.
 7. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
 8. Motion Detector: Built-in digital.

2.3 LENSES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the camera manufacturers.
- B. Description: Optical-quality coated lens, designed specifically for video-surveillance applications and matched to specified camera. Provide color-corrected lenses with color cameras.
 - 1. Auto-Iris Lens: Electrically controlled iris with circuit set to maintain a constant video level in varying lighting conditions.

2.4 POWER SUPPLIES

- A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera, infrared illuminator, and lens.
 - 1. Enclosure: NEMA 250, Type 1.

2.5 INFRARED ILLUMINATORS

- 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. Honeywell International Inc.; Honeywell Video Systems.
 - 2. International Space Optics; Rainbow CCTV products.
 - 3. Merit Li-Lin (USA) Corp.
 - 4. Visiontech.
 - 5. Watec America Corporation.
- B. Description: Lighting fixtures that emit light only in the infrared spectrum, suitable for use with cameras indicated, for nighttime surveillance, without emitting visible light.
 - 1. Field-Selectable Beam Patterns: Narrow, medium, and wide.
 - 2. Rated Lamp Life: More than 8000 hours.
 - 3. Power Supply: 12-V ac/dc or PoE.
- C. Area Coverage: Illumination to 150 feet (50 m) in a narrow beam pattern.
- D. Exterior housings shall be suitable for same environmental conditions as the associated camera.

2.6 CAMERA-SUPPORTING EQUIPMENT

- 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. Bosch Security Systems, Inc.
 - 2. CBC (AMERICA) Corp.
 - 3. COP-USA.
 - 4. Crest Electronics, Inc.
 - 5. Elbex Ltd.; Elbex America Inc.
 - 6. ELMO.

7. EverFocus Electronics Corporation.
 8. GENWAC; a brand of Watec Cameras.
 9. GE Security, Inc.
 10. Honeywell International Inc.; Honeywell Video Systems.
 11. Ikegami Electronics (USA) Inc.
 12. Merit Li-Lin (USA) Corp.
 13. Panasonic Corporation of North America; Panasonic Security Systems.
 14. Pelco.
 15. Samsung Opto-Electronics.
 16. SANYO North America Corporation.
 17. Telpix Electronics, Inc.
 18. Tyco International Limited; Sensormatic products.
 19. VELTEK.
 20. Vicon Industries, Inc.
 21. Videolarm.
 22. Video Mount Products.
 23. Visiontech.
 24. Wren Associates Limited.
- B. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.
- C. Pan Units: Motorized automatic-scanning units arranged to provide remote-controlled manual and automatic camera panning action, and equipped with matching mounting brackets.
1. Scanning Operation: Silent, smooth, and positive.
 2. Stops: Adjustable without disassembly, to limit the scanning arc.
- D. Pan-and-Tilt Units: Motorized units arranged to provide remote-controlled aiming of cameras with smooth and silent operation, and equipped with matching mounting brackets.
1. Panning Rotation: 0 to 355 degrees, with adjustable stops.
 2. Tilt Movement: 90 degrees, plus or minus 5 degrees, with adjustable stops.
 3. Speed: 12 degrees per second in both horizontal and vertical planes.
 4. Wiring: Factory prewired for camera and zoom lens functions and pan-and-tilt power and control.
 5. Built-in encoders or potentiometers for position feedback, and thermostat-controlled heater.
 6. Pan-and-tilt unit shall be available with preset positioning capability to recall the position of a specific scene.
- E. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.
- F. Protective Housings for Fixed and Movable Cameras: 6061 T6 aluminum enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.
1. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display. Tamper switches and central-control unit are specified in Section 281600 "Intrusion Detection."
 2. Camera Viewing Window: Polycarbonate or Lexan window, aligned with camera lens.
 3. Duplex Receptacle: Internally mounted.
 4. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.

5. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
6. Sun shield shall not interfere with normal airflow around the housing.
7. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
8. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.
9. Enclosure Rating: NEMA 4X.

2.7 MONITORS

- 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. [Dell](#)
2. [Hewlett Packard.](#)
3. [Hitachi, Ltd.](#)
4. [Panasonic Corporation of North America.](#)
5. [Samsung Opto-Electronics.](#)
6. [SANYO North America Corporation.](#)

- B. Color:

1. Metal cabinet units designed for continuous operation.
2. Screen Size (Diagonal Dimension): 55 inch.
3. Horizontal Resolution: 4K.
4. Electrical: 120-V ac, 60 Hz.

2.8 NETWORK VIDEO RECORDERS

- 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. AXIS International Inc.
2. Bosch Security Systems, Inc.
3. GE Security, Inc.
4. Hitachi, Ltd.
5. JVC Americas Corp.; JVC Professional products.
6. Panasonic Corporation of North America; Panasonic Security Systems.
7. Samsung Opto-Electronics.
8. SANYO North America Corporation.
9. Tyco International Limited; Sensormatic products.
10. Vicon Industries, Inc.

- B. Description: Network Based Video Recorder

1. Internal hard disk drive, sized for 30 days storage of all cameras at a 30 frame per second rate..
2. Video and audio recording over TCP/IP network.
3. Duplex Operation: Simultaneous recording and playback.
4. Continuous and alarm-based recording.

5. Full-Featured Search Capabilities: Search based on camera, time, or date.
6. Automatic data replenishment to ensure recording even if network is down.
7. Digital certification by watermarking.
8. Internal RAID storage storage.
9. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software.
10. Integrated Web server FTP server functionality.

2.9 IP VIDEO MANAGEMENT SYSTEMS

- 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. .
 2. Bosch Security Systems, Inc.
 3. GE Security, Inc.
 4. Hitachi, Ltd.
 5. JVC Americas Corp.; JVC Professional products.
 6. Milestone Systems.
 7. Panasonic Corporation of North America; Panasonic Security Systems.
 8. Samsung Opto-Electronics.
 9. SANYO North America Corporation.
 10. Tyco International Limited; Sensormatic products.
 11. Vicon Industries, Inc.
- B. Description:
1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
 2. System shall have seamless integration of all video surveillance and control functions.
 3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management.
 4. Shall provide to remote monitoring computers all and any camera displays where indicated on drawings.
 5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
 6. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
- C. Video Motion Sensing: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in SMPTE 170M. Provide an alarm output for each video input.
1. Detect movement within protected zone of intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of two. Reject all other changes in video signal.
- D. Long term Storage: Manage video and Audio storage for economy of operations as follows:
- E. Store all video and audio by time acquired. Erase oldest video to make room for newer video, based on size of storage available.
- F. Provide RAID Storage for video and audio files.

2.10 SIGNAL TRANSMISSION COMPONENTS

- A. Ethernet Cable: Ethernet cable shall be UTP. Comply with Division 27 "Horizontal Cable."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways 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 before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

- 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 271300 "Communications Backbone Cabling" and Section 271500 "Communications Horizontal Cabling."
- F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. 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 alarms, and adjust.

- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- F. Avoid ground loops by making ground connections only at the control station.
 - 1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
- G. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to 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 "Informational 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 (17 to 23 m) 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 system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 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 system.
 5. Provide a written report of adjustments and recommendations.

3.6 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.

3.7 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 310000 - EARTHWORK

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Sections, apply to this section.
- B. Examine all drawings and all other sections of the specifications for requirements therein affecting the work of this section.
- C. Coordinate Work with that of all other trades affecting or affected by the work of this section. Cooperate with such trades to assure the steady progress of all Work under the contract.

1.2 SUMMARY

- A. Section includes all work required to construct the facilities shown on the Drawings.
- B. Earthwork includes, but is not limited to:
 - 1. Topsoil stripping.
 - 2. Proof rolling.
 - 3. Rough grading and shaping.

1.3 RELATED SECTIONS

- A. Site Preparation - Section 311001

1.4 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies: Perform excavation work in compliance with applicable requirements of governing authorities and codes having jurisdiction.
- B. Reference Specifications and Standards:
 - 1. ASTM: D2922 (Nuclear method), or ASTM D1556 (sand-cone method).
 - 2. ASTM: D3017 (Nuclear method), or ASTM D1557 Moisture-Density Relations of Soils, using 10-lb. Rammer and 18-inch Drop.
 - 3. ASTM: D2937, "Density of Soil in Place by the Drive-Cylinder Method."

PART 2 - PRODUCTS

2.1 SOIL MATERIALS - GENERAL

- A. On-site materials: Materials obtained by selective stockpiling of excavated soils. Stockpile only materials acceptable to Soils Engineer.
 - 1. Free of all vegetation, roots, and organic matter, root mat, muck and construction debris as shown on plans.

- B. Borrow materials: Approved materials obtained from a borrow site approved by the Owner.
 - 1. Use only non-expansive clean earth and granular materials, free of vegetation, roots and organic matter, muck, root mat and debris.
 - 2. All material brought on-site must be approved by the Owner.

2.2 SOIL MATERIALS FOR SITE GRADING

- A. Use approved on-site or borrow materials.
- B. All soils at or within 12 inches of the surface in areas which are to be landscaped or sodded shall conform to the following:
 - 1. All soil materials shall be subject to approval by the Engineer.
 - 2. Satisfactory soil materials are defined as those complying with the American Association of State Highway and Transportation Officials (AASHTO) M145, soil classification groups A-1, A-2-4, A-2-5 and A-3.
 - 3. Unsatisfactory soil materials are those defined in AASHTO M145 soil classifications groups A-2-6, A-2-7, A-4, A-5, A-6 and A-7; also, peat and other highly organic soils.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the areas and conditions under which earthwork is to be performed and notify the Owner, in writing, of conditions detrimental to the proper and timely completion of work

3.2 PREPARATION

- A. Layout Work and Reference Points:
 - 1. Before starting layout work, check through and verify all principal governing dimensions and make a general check of elevations and grades called for on the Drawings.
 - 2. Locate benchmarks, monuments and other reference points for elevation and location of new work. Notify the Owner of any apparent discrepancies in indicated locations.
 - 3. Protect reference points from dislocation or damage. Contractor shall notify the Owner's project manager immediately in the event of damage to any reference point. Contractor shall repair or replace the reference point at the expense of the Contractor.
 - 4. Accurately locate new work on site according to Contract Documents.
 - 5. Erect batter boards and set grade stakes securely to remain in place until corners and heights are permanently established.
 - 6. Denote areas allocated for storage of various materials. Select storage and working areas to avoid interference with subsequent operations.
 - 7. Do not proceed with construction work until reference points and layout work have been verified.

3.3 EXCAVATION

- A. Excavation consists of removal and disposal of material of every nature encountered when establishing required grade elevations.
- B. Earth excavation includes removal and disposal of pavements and other obstructions visible on ground surface, underground structures and utilities indicated to be demolished and removed.
- C. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Owner. Unauthorized excavation, as well as remedial work directed by the Owner, and as recommended by Soils Engineer, shall be at the Contractor's expense.
- D. Additional excavation:
 - 1. When excavation has reached required subgrade elevations, notify the Design Engineer, who will make an inspection of conditions. Do not excavate below indicated depths.
 - 2. If inspection indicates unsuitable material and conditions, additional excavation and corrective work will be paid for by means consistent with terms of Contract conditions.

3.4 DEWATERING

- A. All work areas occurring below the groundwater level shall be drained, dewatered and maintained in stated condition while work is taking place at those elevations.
- B. Dewatering methods shall be those selected by the Contractor, subject to approval by the Owner.
- C. Be responsible for maintaining dry excavations and subgrades continuously while work in each area is being done. Water level shall be reduced to sufficient depth to assure that bottom soils are not saturated or develop a quick condition.
- D. Contractor is responsible for obtaining any dewatering permits that may be required.
- E. Take all measures necessary to prevent subsidence of adjacent property, including but not limited to, groundwater recharge swales.

3.5 FILL, BACKFILL AND COMPACTION

- A. Backfill consists of bedding, backfill and restoration of the surface.
- B. Compaction:
 - 1. Proof roll existing ground and bring each 12 inch lift to optimum moisture content before compaction. Add water by uniform sprinkling.
 - 2. When moisture content and condition of each layer is satisfactory, compact to not less than 95 percent of maximum density, or as elsewhere specified.
 - a. Compact areas not accessible to motor-driven equipment with mechanical or heavy hand tampers.

3. Rework compacted areas failing to meet specified maximum density as determined by tests. Re-compact and re-test as required to achieve 95 percent maximum density.
4. Correct unauthorized excavation made below depth indicated, as acceptable to Soils Engineer, at no additional cost to Owner.
5. Landscape areas: Compaction below all landscape, planting or sod areas shall be 90 percent of maximum density for the full depth of fill.
6. Minor structures: Catch basins, and other minor structures shall be supported on bottom and all sides by soils compacted to 95 percent of maximum density.

3.6 GRADING

A. General:

1. Uniformly grade areas within limits of grading and adjacent transition areas as work included in this Section. Smooth finished surface within specified tolerances. Compact with uniform levels or slopes between points where elevations are shown or between such points and existing grades.
 2. Allowable tolerances for grades:
 - a. All cuts and fills shall be graded to necessary subgrade elevations within a tolerance of 0 below to 0.10 feet above grades indicated on Drawings.
 - b. Structures at or on grade shall be within 0.02 feet.
 - c. All elevations and contours shown on the Drawings are to finish grade unless otherwise indicated, and allowance shall be made for pavement thickness and sodding.
- B. Grade areas adjacent to pavement lines to drain away from pavement and to prevent ponding. Finish surfaces free from irregular surface changes.
- C. Grading Surface of Fill Under Pavement: Grade smooth and even, free of voids, compacted as specified and to required elevation.

3.7 FIELD QUALITY CONTROL

A. General

1. All frequency of testing requirements shall be per the geotechnical engineer.

B. Test methods:

1. Maximum density of backfill materials will be determined by ASTM D3017 (Nuclear method), or ASTM D1557 Method A (5-layer method) or ASTM D2937.
2. Field density tests will be determined by ASTM D2922 (Nuclear method), or ASTM D1556 (sand-cone method), unless other applicable method is approved.

C. Required tests:

1. Backfill material: Determine suitability of backfill material not previously evaluated.
2. Maximum density tests: Determine optimum moisture content and maximum density of backfill materials placed and compacted.

3. Compaction inspection: Determine degree of backfill compaction.
4. Bedding conditions: Determine and evaluate condition of bedding to receive utility lines.

D. Inspections and controls:

1. General inspection of stripping of surfaces and removal of root mat, peat, clay and other unsuitable materials or conditions.
2. Detailed inspection of exposed subgrades prior to finishing or placing compacted fills.
3. Continuous control of placing and compacting all compacted fills.
4. Observation and consultation in processes of embankment shaping, safety in excavations, dewatering and identification of materials encountered.

3.8 DAMAGED WORK AND REPAIRS

- A. Repairs: Sections of curbing, concrete and asphalt paving and other permanent features which have been damaged during and as a result of construction operations in connection with this Contract shall be removed and the full section between joints shall be replaced at no additional cost to Owner.
- B. Replacement of grass, shrubs or trees: All grass areas, shrubs or trees which have been rutted or damaged or broken during and as a result of construction operations in connection with this Contract shall be removed and replaced. This shall apply to the grass, shrubs and trees outside the Contract limits as shown on the Drawings.
- C. Protection of graded areas:
 1. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.
 2. Repair and re-establish grades in settled, eroded and rutted areas to specified tolerances.
- D. Reconditioning compacted areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.
- E. Removal from Owner's property: During construction, debris shall be removed from site as soon as practical. See Section for specific removal instructions.

END OF SECTION 310000

SECTION 311001 - SITE PREPARATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section is intended to include the provisions necessary to accomplish all site preparation work required by the Work.
- B. The types of work include, but are not limited to:
 - 1. Clearing, grubbing and disposal of materials and debris resulting from this work.
 - 2. Removing and disposing of above and below grade existing improvements.
 - 3. Tree salvage by Owner.
 - 4. Removal and lawful disposal of existing improvements to be removed or demolished for the Work.
- C. The area requiring site preparation work includes all areas within the Work limits as shown on the Drawings.
- D. Definitions:
 - 1. Clearing: The removal of trees, stumps, duntimber, shrubs, bushes, rubbish and other objectionable matter found at or above original ground level. Should Owner desire selective clearing, other than that shown on the Drawings, Owner will select and mark, or otherwise designate, the trees or ornamentals to remain standing at no additional cost to the Owner.
 - 2. Grubbing: The removal of stumps, roots, boards, logs and other objectionable debris found at or below original ground level.

1.2 JOB CONDITIONS

- A. Protection:
 - 1. Initiate and be responsible for all precautions reasonably necessary for the protection of the Work, protection of areas adjacent to, but outside the Work limits and for the protection of any persons whose injury might result from the failure to take such precautions.
 - 2. Protect improvements at adjoining areas. Provide barricades, coverings or other types of protection necessary to prevent damage to existing improvements indicated to remain in place.
 - 3. Provide for the protection of tops, trunks and roots of existing trees and flora that are to remain on Work site. Do not permit heavy equipment or stockpiles within branch spread.
 - 4. Take all steps necessary to facilitate drainage and prevent water ponding in tree save areas.
 - 5. Water grass, trees and other vegetation which are to remain within the limits of the Contract Work as required to maintain their health during the course of construction operations.
 - 6. Restore any improvements damaged by this Work to their original or better condition, and repair or replace trees and vegetation damaged by construction operations in a manner acceptable to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Provide all materials, equipment and appurtenances required for completion of clearing work, including that required for protection of vegetation and other improvements that are to remain.

PART 3 - EXECUTION

3.1 PERFORMANCE

- A. General:
 - 1. Remove all vegetation, improvements or obstructions in the areas indicated on the Drawings. Remove such items elsewhere on the site or premises as specifically indicated. Removal includes stumps and roots.
 - 2. Verify if the Owner desires to remove any trees prior to clearing.
- B. Clearing and grubbing:
 - 1. Clear and grub the site at new construction areas of all surface vegetation, roots, stumps, rubbish, and objectionable debris.
 - 2. Fill depressions caused by clearing and grubbing operations with satisfactory soil material.
 - 3. Remove all stumps, roots and matted roots to a depth of 12 inches
- C. Removal of Improvements: Remove above-grade and below-grade improvements necessary to permit construction and other work as indicated.
- D. Disposal
 - 1. Remove waste, unsuitable and excess materials from the site daily and dispose of legally at approved locations. Tree material may be kept on-site for up to five days.
 - 2. Burning is not permitted on the property without Owner's written approval.
- E. Selective Clearing and/or Grubbing
 - 1. Special attention shall be given by the Contractor to saving, protecting, and preserving any existing trees, shrubs or other vegetation so designated by the Owner. Selective clearing and/or grubbing shall be performed in locations indicated on the Drawings and other areas specified by the Owner at no additional cost to the Owner. The Owner or his representative will select and mark, or otherwise designate, trees, ornamentals or other vegetation to be preserved outside of the tree save areas shown in the Drawings. Contractor shall install and maintain, until directed otherwise by Owner, a temporary fence around such designated vegetation for a minimum of 10 feet beyond the drip line of the trees, ornamentals, or other vegetation to be preserved. Clearing limits must be approved by the Owner prior to beginning clearing operations.
 - 2. Many improvements located within tree saves will require selective clearing and grubbing within the tree save areas. These improvements include hardscape utilities, drainage, etc. These items are shown on the Drawings as to general location. However, exact locations

will be determined by the Owner in the field. Vegetation remaining after these operations shall be protected by temporary fence and hay bales/silt fence in the same manner as the original exterior of the tree save area.

END OF SECTION 311001

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SECTION 312334 - EXCAVATING AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items necessary for the proper dewatering, excavating, shoring, sheeting, bracing, trenching, backfilling and all other earthwork operations required for utility and other underground lines and appurtenances.

1.2 RELATED SECTIONS

- A. Earthwork - Section 310000
B. Potable and Reuse Water Distribution Systems - Section 331110

1.3 QUALITY ASSURANCE

A Tests and inspections:

1. Required tests:
2. Backfill material: Determine suitability of backfill and bedding material not previously evaluated.
3. Maximum density tests: Determine optimum moisture content and maximum density of backfill and bedding materials placed and compacted.
4. Bedding conditions: Determine and evaluate condition of bedding to receive utility lines.
5. Compaction inspection: Determine degree of backfill compaction.

B Reference Specifications and Standards:

1. ASTM D1557 Moisture-Density Relations of Soils, using 10 lb. Rammer and 18 inches Drop.
2. AASHTO: T-180 (Modified Proctor).

PART 2 - PRODUCTS

2.1 BACKFILL MATERIAL

A. TYPE A BACKFILL:

1. Select bedding material shall be clean, well-graded, rounded coarse aggregate or crushed rock of 3/4-inch maximum size and 3/8-inch minimum size. When tested in accordance with ASTM D422 it shall conform to the following gradation requirements:

Passing a 1-inch sieve	-	100 Percent
Passing a 3/4-inch sieve	-	90-100 Percent
Passing a 3/8-inch sieve	-	20-55 Percent
Passing a No. 4 sieve	-	0-10 Percent

B. TYPE B BACKFILL:

1. Type B backfill shall be a select granular material, free from organic matter and of such size and gradation that desired compaction can readily be attained. When tested in accordance with ASTM D422, it shall conform to the following gradation requirements.

Passing a 1-1/2 inch sieve	-	95 Percent (Min.)
Passing a No. 200 sieve	-	10 Percent (Max.)
Coefficient of Uniformity	-	6 or Greater
Sand Equivalent	-	35 Percent or Greater

2. The maximum aggregate size shall not exceed 3 inches. This material may be clean natural sand or gravel, imported quarry waste or select excavated material, provided that such material consists of loam, sand, sandy clay loam, gravel or other materials of the GM/GC classification, as classified in accordance with ASTM D2487. The Contractor shall submit soil reports ten (10) days in advance of intended use for approval by the Engineer and the Owner.

C. ORDINARY BACKFILL:

1. Ordinary backfill shall be material obtained from the Contractor's excavations. Such materials shall be free of debris, deleterious materials, broken concrete or paving materials, root masses, organic materials, boulders, rocks or stones larger than 3 inches and expansive soils.

D. DEFICIENCY OF BACKFILL:

1. Where excavated material is indicated as backfill (ordinary backfill) on the Drawings or specified herein, and there is a deficiency due to the rejection of part of the material, the required quantity of sand, gravel or other approved backfill material (Type A or B backfill) shall be obtained from a source secured by the Contractor and approved by the Owner.

PART 3 - EXECUTION

3.1 PROTECTION

- A. Protect from damage, all existing on-site features scheduled or indicated to remain, including trees and other flora.
 1. Do not allow earthmoving equipment within the branch spread perimeter (drip line) of existing trees.
 2. Do not cut tree roots over 2 inches in diameter without prior approval.
 3. Support trees during excavation in an approved manner.
- B. Where utility line excavation occurs in lawn, grassed or landscaped areas, carefully remove and stockpile sod and plants to preserve them for transplanting.

1. Excavated material from trenches may be placed on the lawn or grass provided a drop cloth or other approved method is employed to protect the lawn or grass from permanent damage. Do not keep stockpiled materials on lawn or grass for more than 72 hours.
 2. Immediately after completion of backfilling and testing of utility lines, replace sod and replant plants in a manner so as to restore the lawn, grass and landscaping to its original condition. Replace damaged landscaping as part of the work of this Section.
- C. Where utility line excavation occurs in paved areas, saw-cut the existing pavement along straight, uniform lines such that the amount of pavement cut and removed shall be the minimum consistent with safe excavation practices.
1. Do not use removed pavement or base material as backfill.
 2. Replace removed pavement with new pavement to match existing in accordance with the Drawings and these Specifications.
- D. Maximum length of open trenches: 350 feet. Cover or barricade all open trenches during work hours and at the close of each work day. All guest areas shall be separated from open trenches by construction fencing at all times.
- E. Utilities:
1. Where excavation for utility lines occurs near existing utilities, whether indicated or not on the Drawings, the Contractor shall be responsible to maintain existing utility services fully operational. Protect and support utility lines in a manner to prevent any damage. Method of protection is subject to utility's approval.
 2. In the event that damage does occur, make repairs or replacement immediately in an approved manner, as part of work of this Section.
 3. Remove abandoned lines encountered during excavating and dispose of off site.

3.2 PIPELINE TRENCH CONSTRUCTION

- A. Trench excavating and backfilling, including sheeting, shoring, bracing, dewatering, foundation, bedding and compaction, and the furnishing and disposal of material shall be performed in such a manner as to promote the safe and expedient execution of the work.
1. It shall be the Contractor's responsibility to contact utilities not less than five (5) working days prior to the commencement of trenching and excavation to obtain an excavation permit and to locate and flag all existing underground utilities at the work site.
 2. The excavation and preparation of trenches shall not proceed in advance of pipe installation more than 100 feet, except as approved by the Owner. Trenching shall not, under any conditions, exceed the quantity of pipe that can be bedded, inspected, tested, backfilled and compacted in one working day.
 3. All excavations shall be made by open cut unless indicated otherwise in these Specifications or on the Drawings.
 4. Excavation in close proximity to existing utilities shall be performed in such a manner, so as to prevent damage to the lines.
 5. The sides of trenches shall be kept as nearly vertical as possible from the trench bottom to a level 1 foot above the top of the pipe.

6. The trench bottom shall be excavated to true line and grade and shall not be less than 18 inches wide nor more than 24 inches wider than the outside diameter of the pipe, so that a clear space of from 9 to 12 inches is provided on each side of the pipe.
7. The minimum trench width for pipe 6 inches and smaller shall not be less than 24 inches.
8. When obstructions that are not shown on the Drawings are encountered during the progress of the work that interfere such that a revision to the Drawings is required, the Engineer, with the approval of the utility, will revise the Drawings, or order the removal, relocation or reconstruction of the obstruction.
9. Excavated material shall not be placed in any manner that will obstruct the Work or endanger the workmen, obstruct sidewalks, entrances, streets or structures. Excavation and placement of excavated materials shall comply with all federal, state and local regulations.
10. Removal of pavement and roadway surfaces shall be a part of the trench excavation. Pavement shall be saw cut to insure the breaking of the pavement along straight lines. Broken pavement and unsuitable soils from the excavation shall be removed from the work site.
11. Roadway cuts shall be made between the hours of 2 a.m. and 6 a.m. to minimize disruption of traffic. Roadways shall be in safe operating condition no later than 7:00 a.m. The Contractor shall provide safe, temporary detours for traffic during open cut construction.
12. When the subgrade is found to contain materials such as ashes, cinders, refuse, broken concrete, logs, root masses, organic material or other unsuitable or unstable material, the Contractor shall remove all such material to a minimum of 6 inches below the trench bottom elevation, and replace with clean stable backfill material.
13. Blasting and the use of explosives shall not be permitted.
14. Boring and jacking, where required, shall be conducted with no interference with traffic, even if this should require that the work be done between the hours of 2 a.m. and 6 a.m.
15. Trees, shrubs, fences, structures and other property shall be protected during construction unless their removal or demolition is shown on the Drawings or called for in the Specifications.
 - a. Cutting of tree roots or branches shall be performed only as specified and approved by the Owner.
 - b. Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers, water mains, force mains, electrical and communications and other obstructions encountered in the progress of the work shall be the responsibility of the Contractor.
 - c. All properties that have been disturbed in the course of the work shall be restored to their original condition.

3.3 SHEETING, SHORING AND BRACING

- A. The Contractor shall furnish, install and maintain sheeting, bracing and shoring required to support the sides of the excavation, and to prevent any movement which may damage adjacent utilities, pavements or structures, damage or delay the work or endanger life and health. All voids outside the supports shall be immediately filled and compacted.
- B. All sheeting, bracing and shoring to be used shall be designed by a Registered Professional Engineer, and shall be in accordance with OSHA Standard 1926-606, Subpart P, Excavation, Trenching and Shoring and the Trench Safety and Health Act.

- C. Where it is impractical to remove shoring and bracing, obtain approval to leave it in place. Record locations of such "in place" shoring and bracing on project record documents.
- D. Wood sheeting left in place shall be pressure treated. Prior to abandonment, the sheeting shall be cut to a level at least 30 inches below finished grade.
- E. Steel sheeting left in place shall be as specified in ASTM A328. Prior to abandonment, the sheeting shall be cut to a level at least 30 inches below finished grade.

3.4 DEWATERING AND DRAINAGE

- A. All piping shall be laid "in the dry" unless otherwise approved by the Owner. All dewatering shall conform to the requirements of Dewatering Specification.

3.5 TRENCH STABILIZATION

- A. When the trench bottom is found to contain unsuitable material which is unstable to such a degree that in the judgment of the Engineer it cannot be removed, a foundation for the pipe, structure and/or appurtenance shall be constructed using piling, treated timber, concrete or other material approved by the Engineer.
 - 1. Unsuitable materials are soils, exposed at the trench bottom that are compressible, expansive, contain extraneous rubble, offer uneven foundation support, or have a natural moisture content 3 percent in excess of the soils optimum moisture content.
 - 2. Unsuitable materials/soils shall include, but not be limited to, muck, peat, expansive clays, boulders, soils in a quick condition, rubble, any portion of trees, roots or similar vegetation, wood or other unyielding material.
- B. The Contractor shall notify the Engineer immediately when unstable material is encountered. The Engineer will investigate the questionable material to determine its stability.
 - 1. Where the Engineer determines that unstable material is present below the pipe envelope which will not provide adequate support for the pipe, the Contractor shall remove the unstable material and replace with a minimum of 6 inches of Type A backfill up to the bottom of the pipe envelope.

3.6 BACKFILLING, COMPACTION AND TESTING

- A. The Contractor shall not perform any backfilling operations other than those that are necessary to hold the pipe in place until soil test samples have been taken, locations recorded, the pipeline tested, inspected and released for backfilling.
- B. BEDDING:
 - 1. See specific utility sections for bedding details.
- C. HAUNCHING:

1. After the pipe has been properly bedded and inspected, ordinary backfill, as specified in 2.01C. of this Section, as available, or Type B backfill shall be carefully placed and compacted, under and around the pipe, up to the springline of the pipe.
 - a. Ordinary or Type A or B backfill material shall be placed in loose horizontal lifts equally on both sides of the pipe. Lifts shall not exceed 6 inches in loose depth.
 - b. The backfill material shall be spaded, walked-in and compacted with hand tampers to obtain a relative density of not less than 95 percent of the maximum density as determined by ASTM D1557.
 - c. When one lift is completed and compacted on both sides of the pipe, subsequent lifts shall be placed and compacted up to the springline of the pipe.

D. PIPE ENVELOPE:

1. After haunching has been placed, compacted, inspected, tested and accepted, ordinary backfill (as available) or Type A or B backfill shall be carefully placed around and over the pipe in loose horizontal lifts not to exceed 12 inches in depth.
 - a. The backfill material shall be walked-in and compacted with tampers to obtain a relative density of 90 percent of the maximum density. Where trench depths are 6 feet or less to the top of the pipe, the minimum allowable relative density shall not be less than 95 percent of the maximum density.
 - b. When the first lift is compacted and complete, subsequent lifts shall be placed and compacted until the pipe envelope is complete to 1 foot above the pipe.

E. BACKFILL AND COMPACTION:

1. Above the level of the pipe envelope, the trench shall be backfilled with ordinary backfill, placed in horizontal lifts and compacted by power operated tampers or vibratory equipment. The Contractor shall compact each successive lift to the specified relative density prior to placing subsequent 1 foot maximum lifts.
2. The Contractor shall not achieve compaction by the use of heavy rolling equipment or by running heavy construction equipment on or in the trench. Backfilling and compaction shall have been completed, tested and the degree of compaction verified before heavy equipment is operated over the trench.
3. Compaction tests shall, at a minimum, be conducted every 100 feet.
4. Puddling or flooding with water to achieve compaction shall not be permitted.
5. When unsatisfactory compaction is revealed, the Contractor shall immediately re-excavate the trench from the unsatisfactory area to the nearest points of satisfactory compaction testing, replace and re-compact the backfill to the required relative densities over the entire depth of the trench.

F. PARTIAL BACKFILL DURING TESTING:

1. When conditions require that pipe testing should be accomplished before completion of backfilling or with pipe joints accessible for examination, sufficient backfill material shall be placed over the pipe barrel, between the joints to prevent pipe movement.

3.7 ADJUSTMENT AND CLEANING

A. Surface restoration:

1. Restore surfaces areas over trenches equal to conditions which existed prior to start of work or better.
2. Reconstruct surfaces in accordance with applicable sections of the Specifications.

B. Disposal:

1. Debris: Remove and dispose of all rubbish, debris, and vegetation as they accumulate.
 - a. Dispose of debris off site.
 - b. Excess soil: Stockpile on a site approved by the Engineer and Owner

END OF SECTION 312334

SECTION 312335 - EXCAVATING AND BACKFILLING FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items necessary for the proper installation of the structure subgrade.
- B. Section includes:
 - 1. Excavating, backfilling and compacting for structures.
 - 2. Restore grades to required elevations.
 - 3. Remove excess materials from site.
 - 4. Pumping and dewatering.
 - 5. Sheet piling of excavations.

1.2 RELATED SECTIONS

- A. Earthwork - Section 310000
- B. Excavating and Backfilling for Utilities - Section 312334

1.3 QUALITY ASSURANCE

- A. Tests and inspections:
 - 1. Test methods:
 - a. Maximum density of backfill materials will be determined by ASTM D1557 Method A (5-layer method), unless other applicable method is approved.
 - b. Field density tests will be determined by ASTM D2922 (Nuclear method), or ASTM D1556 (sand-cone method), unless other applicable method is approved.
 - 2. Required tests:
 - a. Backfill material: Determine suitability of backfill and bedding material not previously evaluated.
 - b. Maximum density tests: Determine optimum moisture content and maximum density of backfill and bedding materials placed and compacted.
 - c. Compaction inspection: Determine degree of backfill compaction.
- B. Reference specifications and standards:
 - 1. ASTM: D2922 (Nuclear method), or ASTM D1556 (sand-cone method).
 - 2. ASTM D1557 Moisture-Density Relations of Soils, using 10 lb. Rammer and 18 inches Drop.

PART 2 - PRODUCTS

2.1 MATERIALS

A. On-site and borrow materials:

1. Conforming to these specifications.

PART 3 - EXECUTION

3.1 PROTECTION

- A. Protect public and adjacent properties, on and off site, in accord with applicable laws and ordinances. Protect and provide fencing as detailed in the drawings
- B. Protect from damage, all existing on-site features scheduled or indicated to remain, including flora scheduled to remain.
1. Do not allow earthmoving equipment within the branch spread perimeter (drip line) of existing trees.
- C. Utilities:
1. Protect and support active utility lines in a manner to prevent damage. Methods subject to Owner's approval.
 2. Remove abandoned lines encountered during excavation and dispose of off-site.
 - a. Report unidentified lines to Owner for determination as to "dry" or "abandoned" prior to removal.
 3. Capping and rerouting of indicated active utility lines encountered during grading operations will be performed as part of the work of this section.
- D. Cribbing and shoring:
1. Provide temporary or permanent cribbing, sheeting and shoring as necessary to safely retain earth banks and protect excavations from caving or other damage.
 2. Be responsible for design, installation and maintenance of cribbing, sheeting and shoring. Remove temporary cribbing and shoring after use.

3.2 STRIPPING

- A. Stockpile materials from excavations suitable for use in fill and backfill.
- B. Materials not approved for use as topsoil, fill or backfill, and excess excavating materials shall be removed from site and disposed of properly, subject to Owner's written approval.

3.3 EXCAVATING

- A. Excavate materials of every nature to dimensions and elevations indicated. Use equipment of suitable type for materials and conditions involved.
- B. Extend excavation a sufficient distance from walls to allow for forming and shoring, application of waterproofing, installation of services and approvals. Do not excavate below indicated

depths.

- C. Correct unauthorized excavation made below depths indicated, as recommended by soils engineer at no additional cost to Owner.

3.4 FILL, BACKFILL AND COMPACTION

A. Fill and backfill:

1. Place fill and backfill in layers that will uniformly compact to the required densities, but not in loose layers more than 12-15 inches thick.
 - a. Place backfill only after walls are supported by completion of interior floor systems or are braced to resist the imposed loading.
 - b. Place backfill against walls below grade after waterproofing systems have been completed and approved.
 - c. Protect waterproofing systems during backfill operations.
 - d. If waterproofing is damaged, do not continue backfilling until damage is repaired as approved by Owner.
2. Restore grades to indicated elevations.

B. Compaction:

1. Proof roll existing ground prior to filling.
2. Bring each layer to optimum moisture content before compaction. Add water by uniform sprinkling.
3. When moisture content and condition of each layer is satisfactory, compact to not less than 95% of maximum density.
 - a. Compact areas not accessible to motor-driven equipment with mechanical or heavy hand tampers.
4. Rework compacted areas failing to meet specified maximum density, as determined by tests. Re-compact and re-test as required to achieve 95% maximum density.

END OF SECTION 312335

SECTION 312500 - EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Erosion and sedimentation control requirements:

1. All erosion, sedimentation and water pollution control features shall be in place or relocated as designated on the plans prior to the start of any clearing, grubbing, grading or construction. Contractor shall be responsible for the installation and maintenance of all temporary erosion control features.
2. Location of the control features shall be in accordance with the Drawings or as required to facilitate drainage and control erosion and sedimentation within and adjacent to the site.
3. Control features are defined as, but not limited to, swales, berms, silt fences, silt barriers and temporary fences.

1.2 SUBMITTALS

- A. Product data: Manufacturers literature, application instructions and samples.
- B. List of materials and their characteristics for other erosion control items.
- C. Erosion control plan.

1.3 CONTROL OF CONTRACTOR'S OPERATIONS WHICH MAY RESULT IN WATER POLLUTION

- A. Take sufficient precautions to prevent pollution of streams, canals, lakes, reservoirs, wetlands and other sensitive areas with silt, sediment, fuels, oils, bitumens, calcium chloride, or other harmful materials. Conduct and schedule operations so as to avoid or otherwise minimize pollution or siltation of such streams, etc. and to avoid interference with movement of migratory fish. Do not dump the residue from dust collectors or washers into any water body.
- B. Construction operations in rivers, streams, lakes, tidal waters, reservoirs, canals, and other impoundments shall be restricted to those areas where it is necessary to perform filling or excavation to accomplish the work shown in the Contract Documents and to those areas which must be entered to construct temporary or permanent structures. As soon as conditions permit, promptly clear rivers, streams, and impoundments of all obstructions placed therein or caused by construction operations.
- C. Except as necessary for construction, do not deposit excavated material in rivers, streams, canals, or impoundments, or in a position close enough thereto, to be washed away by high water or run-off.

- D. Where pumps are used to remove highly turbid waters from enclosed construction areas such as cofferdams or forms, treat the water prior to discharge into waterways. Pump the water into grassed swales, appropriately vegetated areas, or sediment basins, or confine it by an appropriate enclosure such as siltation curtains when other methods are not considered appropriate. Do not contaminate waterways.
- E. Do not disturb lands or waters outside the limits of construction, unless approved in advance and in writing by the Owner. No operations within non-permitted wetlands or upland buffers are allowed.

1.4 START OF WORK

- A. Do not start work until erosion control measures are in place.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Silt Barriers:

1. Two types of silt barriers shall be installed in accordance with the plans: silt barriers installed on the ground and floating silt barriers.
2. Silt barriers (filter fabric) shall be synthetic and contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six (6) months of expected usable construction life at a temperature range of 0 to 120 degrees F.
3. Filter fabric shall be a pervious sheet of propylene, nylon or polyester and shall be certified by the manufacturer or supplier to conform to the following specifications:
 - Filter efficiency (Test VTM-51): 75 percent.
 - Minimum tensile strength at 20 percent elongation (Test ASTM D 5034 and 5035): 120 pounds.
 - Tear strength: 50 pounds.
4. Contractor shall submit filter fabric material specifications and installation configuration prior to start of construction.
5. Silt barriers shall be maintained in place and shall become the property of Owner.
6. Filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter fabric shall be spliced together only at a support post, with a 6 inch overlap, and securely sealed.
7. The following items shall be installed and maintained in accordance with the applicable sections of the FDOT and local government Standard Specifications:
 - a. Temporary silt fences and staked silt barriers
 - b. Floating silt barrier
8. Temporary Fence
 - a. Brightly colored fence as manufactured by Mirafi, product Mirasafe, or approved equal.
 - b. Material shall be 4 feet high, attached to 6 feet metal posts at 12 feet centers. Posts shall be driven 18 inches into ground.

PART 3 - EXECUTION

3.1 GENERAL

- A. Temporary erosion control features shall consist of, but not be limited to, temporary grassing, temporary sodding, temporary mulching, sandbagging, slope drains, sediment basins, artificial coverings, berms, baled hay or straw, floating silt barriers, staked silt barriers and staked silt fences. Design details for some of these items may be found in the Water Quality Section of the applicable edition of the FDOT Roadway and Traffic Design Standards. All of these items shall be constructed in accordance with applicable sections of the FDOT Standard Specifications for Road and Bridge Construction.
- B. Incorporate permanent erosion control features into the Work at the earliest practical time. Correct conditions, using temporary measures, that develop during construction to control erosion prior to the time it is practical to construct permanent control features.
- C. Construct temporary and permanent erosion and sediment control measures and maintain them to prevent the pollution of adjacent water ways in conformance with the laws, rules and regulations of Federal, State and local agencies.
- D. Copies of approved permits will be provided to the Contractor for his review and use. Contractor shall be required to comply with all General and Special Conditions noted within the permit by the particular permitting agency. The Contractor shall maintain copies of these permits on the job site at all times.

3.2 INSTALLATION

- A. The following items shall be installed in accordance with the FDOT Standard Specifications for Road, Bridge and Utility Construction. The procedures are only generally described herein.
 - 1. Temporary Grassing: This work shall consist of furnishing and placing grass seed.
 - 2. Temporary Sod: This work shall consist of furnishing and placing sod.
 - 3. Temporary Mulching: This work shall consist of furnishing and applying a two-inch to four-inch thick blanket of straw or hay mulch and then mixing or forcing the mulch into the top two inches of the soil in order to temporarily control erosion. Only undecayed straw or hay, which can readily be cut into the soil, shall be used. Other measures for temporary erosion control such as hydro-mulching, chemical adhesive soils stabilizers, etc., may be substituted for mulching with straw or hay with the approval of the Owner. When permanent grassing operations begin, temporary mulch materials shall be plowed under in conjunction with preparation of the ground.
 - 4. Sandbagging: This work shall consist of furnishing and placing sandbags in configurations, so as to control erosion and siltation.
 - 5. Slope Drains: This work shall consist of constructing slope drains, utilizing pipe, fiber mats, rubble, cement concrete, asphaltic concrete plastic sheeting, or other acceptable materials, in

accordance with the FDOT Roadway and Traffic Design Standards or as may be approved as suitable to adequately perform the intended function.

6. Sediment Basins: Sediment basins shall be constructed in accordance with the details shown in FDOT Roadway and Traffic Design Standards or as suitable to adequately perform the intended function. Sediment basins shall be cleaned out as necessary.
7. Artificial Coverings: This work shall consist of furnishing and applying fiber mats, netting, plastic sheeting, or other approved covering to the earth surfaces.
8. Berms: This work shall consist of construction of temporary earth berms to divert the flow of water from an erodible surface.
 - a. This work shall consist of construction of baled hay or straw dams or earth berms to protect against downstream accumulations of silt. The baled hay or straw dams shall be constructed in accordance with the details shown in FDOT Roadway and Traffic Design Standards.
 - b. The berm or dam shall be placed so as to effectively control silt dispersion under conditions present on this Work. Alternate solutions and usage of materials may be used if approved.

3.3 SILT BARRIERS

- A. Silt barriers shall be installed and maintained at the locations shown on the plans. The Contractor is required to prevent the possibility of silting onto any adjacent parcel.
- B. Silt barrier shall be of the staked type and stakes shall be installed as indicated in the drawings.
- C. The height of the silt barrier fabric shall be a minimum of 42 inches.
- D. The stakes shall be 2 inch x 4 inch wood, 5 feet long and shall be spaced a maximum of 10 feet apart at the barrier location and driven securely into the ground.
- E. A trench shall be excavated approximately 4 inches wide by 4 inches deep along the line of stakes. The filter fabric shall be tied or stapled to the wooden stakes and 8 inches of fabric shall be extended into the trench. The staples shall be heavy duty wire and at least 1/2 inch long. The trench shall then be backfilled and the soil compacted over the filter fabric.

3.4 FLOATING SILT BARRIERS

- A. Floating silt barriers shall be located as shown on the Drawings and shall be in place prior to the start of any construction or grading.
- B. Floating silt barriers shall meet or exceed the FDOT Roadway and Traffic Design Standards, Index No. 103, Floating Silt Barrier. Contractor shall submit filter fabric material specifications and installation configuration for approval prior to the start of construction.

3.5 TEMPORARY FENCE

- A. Furnish, install and maintain on wetland lines, buffer lines, tree save lines and otherwise as shown on plans. Attach silt barrier to the temporary fence.
- B. Follow manufacturer's installation recommendations.

3.6 MAINTENANCE

- A. Silt barriers and temporary fences shall be inspected immediately after each rainfall and at least once a day during periods of prolonged rainfall. Any repairs shall be made immediately.
- B. Should the fabric on a silt barrier or temporary fence decompose or become ineffective, the installation shall be repaired or replaced immediately at no additional cost to the Owner. If the Contractor fails to repair or replace the items as above, the Owner shall have the right to stop work without additional cost to the Owner until such time as the repair or replacement has been made.
- C. Sediment deposits shall be removed after each storm event. The Contractor will repair and restore the installations to a working and effective condition to the satisfaction of the Owner.
- D. At the completion of all work, the silt barriers and the temporary fences will be removed and disposed by the Contractor if directed by the Owner.
- E. Any sediment deposits in place after the silt fence or filter barrier is no longer required shall be dressed to conform to the existing grade and prepared for seeding or sodding.

3.7 PROTECTION DURING SUSPENSION OF CONTRACT TIME

- A. In the event that it is necessary that the construction operations be suspended for any appreciable length of time, shape the top of the earthwork in such a manner as to permit run-off of rainwater and construct earth berms along the top edges of embankments to intercept run-off water. Provide temporary slope drains to carry run-off from cuts and embankments which are located in the vicinity of rivers, streams, canals, lakes and impoundments. Should such preventative measures fail, immediately take such other action as necessary to effectively prevent erosion and siltation.

END OF SECTION 312500

SECTION 321123 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 COMPOSITION

- A. Coarse aggregate shall consist of naturally occurring materials such as gravel, or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this Section.
- B. Coarse aggregate for use in nonstructural concrete applications or hot bituminous mixtures may also consist of reclaimed Portland cement concrete meeting the requirements of Part 5. Washing of this material will not be required if the requirements of Section 1.2 for maximum percent of material passing the No. 200 sieve can be met without washing.
- C. Materials substantially retained on the No. 4 sieve, shall be classified as coarse aggregate.
- D. Approval of mineral aggregate sources shall be in accordance with specification.

1.2 DELETERIOUS SUBSTANCES

- A. All coarse aggregates shall be reasonably free of clay lumps, soft and friable particles, salt, alkali, organic matter, adherent coatings, and other substances not defined which may possess undesirable characteristics. The weight of deleterious substances shall not exceed the following percentages:

Coal and lignite (AASHTO T 113).....	1.00
Soft and friable particles (AASHTO T 112)*.....	2.00
Clay lumps (AASHTO T 112)*	2.00
Plant root matter (visual inspection in AASHTO T 27)****	0.005
Wood and wood matter (visual inspection in AASHTO T 27)****	0.005
Cinders and clinkers.....	0.50
Free shell**	1.00
Total Material passing the No. 200 sieve (FM 1-T 011) At Source with Los Angeles Abrasion less than or equal to 30	2.50
At Source with Los Angeles Abrasion greater than 30.....	1.75
At Point of Use.....	3.75
Fine-Grained Organic Matter (AASHTO 194).....	0.03
Chert (less than 2.40 specific gravity SSD) (AASHTO T-113)***	3.00

*The maximum percent by weight of soft and friable particles and clay lumps together shall not exceed 3.00.

**Aggregates to be used in asphalt concrete may contain up to 5% free shell. Free shell is defined as that portion of the coarse aggregate retained on the No. 4 sieve consisting of loose, whole, or broken shell, or the external skeletal remains of other marine life, having a ratio of the maximum length of the particle to the shell wall thickness exceeding five to one. Coral, molds, or casts of other shells, and crushed clam and oyster shell indigenous to the formation will not be considered as free shell.

***This limitation applies only to coarse aggregates in which chert appears as an impurity. It is not applicable to aggregates which are predominantly chert.

****Plant root matter, and wood and wood matter shall be considered deleterious when any piece exceeds two inches in length or 1/2 inch in width.

1.3 PHYSICAL PROPERTIES

- A. Coarse aggregates shall meet the following physical property requirements, except as noted herein:

Los Angeles Abrasion (FM 1-T 096).....	Maximum loss 45%
Soundness (Sodium Sulfate) AASHTO T104.....	Maximum loss 12%*
Flat or elongated pieces**.....	Maximum 10%

*For source approval - Aggregates exceeding soundness loss limitations will be rejected unless performance history shows that the material will not be detrimental for Portland Cement Concrete or other intended usages.

**A flat or elongated particle is defined as one having a ratio between the maximum and the minimum dimensions of a circumscribing prism exceeding five to one.

1.4 GRADATION:

- A. Coarse aggregates shall conform to the gradation requirements of Table 1, when the stone size is specified. However, Table 1 is waived for those aggregates intended for usage in bituminous mixtures, provided the material is graded on sieves specified in production requirements contained in this specification, and meets uniformity and bituminous design requirements.

TABLE 1 Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	4 inches	3 1/2 inches	3 inches	2 1/2 inches	2 inches	1 1/2 inches	1 inch
1	3 1/2 to 1 1/2 inches	100	90 to 100	-	25 to 60	-	0 to 15	-
2	2 1/2 inches to 1 1/2 inches	-	-	100	90 to 100	35 to 70	0 to 15	-
24	2 1/2 inches to 3/4 inch	-	-	100	90 to 100	-	25 to 60	-
3	2 inches to 1 inch	-	-	-	100	90 to 100	35 to 70	0 to 15
357	2 inches to No. 4	-	-	-	100	95 to 100	-	35 to 70
4	1 1/2 inches to 3/4 inch	-	-	-	-	100	90 to 100	20 to 55
467	1 1/2 inches to No. 4	-	-	-	-	100	95 to 100	-
5	1 inch to 1/2 inch	-	-	-	-	-	100	90 to 100
56	1 inch to 3/8 inch	-	-	-	-	-	100	90 to 100
57	1 inch to No. 4	-	-	-	-	-	100	95 to 100
6	3/4 inch to 3/8 inch	-	-	-	-	-	-	100
67	3/4 inch to No. 4	-	-	-	-	-	-	100
68	3/4 inch to No. 8	-	-	-	-	-	-	-
7	1/2 inch to No. 4	-	-	-	-	-	-	-
78	1/2 inch to No. 8	-	-	-	-	-	-	-
8	3/8 inch to No. 8	-	-	-	-	-	-	-
89	3/8 inch to No. 16	-	-	-	-	-	-	-
9	No. 4 to No. 16	-	-	-	-	-	-	-
10	No. 4 to 0	-	-	-	-	-	-	-

TABLE 1 (Continued) Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No.50
1	3 1/2 inches to 1 1/2 inches	0 to 5	-	-	-	-	-	-
2	2 1/2 inches to 1 1/2 inches	0 to 5	-	-	-	-	-	-
24	2 1/2 inches to 3/4 inch	0 to 10	0 to 5	-	-	-	-	-
3	2 inches to 1 inch	-	0 to 5	-	-	-	-	-
357	2 inches to No. 4	-	10 to 30	-	0 to 5	-	-	-
4	1 1/2 inches to 3/4 inch	0 to 15	-	0 to 5	-	-	-	-
467	1 1/2 inches to No. 4	35 to 70	-	10 to 30	0 to 5	-	-	-
5	1 inch to 1/2 inch	20 to 55	0 to 10	0 to 5	-	-	-	-
56	1 inch to 3/8 inch	40 to 85	10 to 40	0 to 15	0 to 5	-	-	-
57	1 inch to No. 4	-	25 to 60	-	0 to 10	0 to 5	-	-
6	3/4 inch to 3/8 inch	90 to 100	20 to 55	0 to 15	0 to 5	-	-	-
67	3/4 inch to No. 4	90 to 100	-	20 to 55	0 to 10	0 to 5	-	-
68	3/4 inch to No. 8	90 to 100	-	30 to 65	5 to 25	0 to 10	0 to 5	-
7	1/2 inch to No. 4	100	90 to 100	40 to 70	0 to 15	0 to 5	-	-
78	1/2 inch to No. 8	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	-
8	3/8 inch to No. 8	-	100	85 to 100	10 to 30	0 to 10	0 to 5	-
89	3/8 inch to No. 16	-	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9	No. 4 to No. 16	-	-	100	85 to 100	10 to 40	0 to 10	0 to 5
10	No. 4 to 0	-	-	100	85 to 100	-	-	-
NOTE: The gradations in Table 1 represent the extreme limits for the various sizes indicated, which will be used in determining the suitability for use of coarse aggregate from all sources of supply. For any grade from any one source, the gradation shall be held reasonably uniform and not subject to the extreme percentages of gradation specified above.								

PART 2 - NATURAL STONES

2.1 NATURAL STONES

- A. Course aggregate may be processed from gravels, granites, limestones, dolomite, sandstones, or other naturally occurring hard, sound, durable materials meeting the requirements of this Section.

2.2 GRAVELS

- A. Gravel shall be composed of naturally occurring quartz, free from deleterious coatings of any kind. The minimum dry-rodded weight AASHTO T 19 shall be 95 lb/ft³.
- B. Crushed gravel shall consist of a minimum of 85%, by weight, of the material retained on the No. 4 sieve, having at least three fractured faces.

2.3 GRANITES

- A. Coarse aggregate produced from the crushing of granites shall be sound and durable. For granites to be used in bituminous mixtures and surface treatments, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T 096). Maximum amount of mica schist permitted is 5% (FM 5-584).

2.4 LIMESTONES, DOLOMITE AND SANDSTONE

- A. Coarse aggregates may be produced from limestone, dolomite, sandstones, and other naturally occurring hard, durable materials meeting the requirements of this Section.
- B. Pre-Cenozoic limestones and dolomite shall not be used as crushed stone aggregates either coarse or fine for Asphalt Concrete Friction Courses, or any other asphalt concrete mixture or surface treatment serving as the final wearing course. This specifically includes materials from the Ketone Dolomite (Cambrian) Newala Limestone (Mississippian), and Northern Alabama and Georgia.
- C. As an exception to the above up to 20% fine aggregate from these materials may be used in asphalt concrete mixtures other than Friction Courses which serve as the final wearing course.

2.5 CEMENTED COQUINA ROCK

- A. For Cemented Coquina Rock to be used in bituminous mixtures, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T 096) provided that the amount of material finer than No. 200 generated during the Los Angeles Abrasion test is less than 18%.

PART 3 - MANUFACTURED STONES

3.1 SLAGS:

- A. Coarse aggregate may be produced from molten nonmetallic by-products consisting essentially of silicates and aluminosilicates of calcium and other bases, such as air-cooled blast-furnace slag or phosphate slag, provided it is reasonably uniform in density and quality, and reasonably free from deleterious substances as specified in 901-1.2. In addition, it must meet the following specific requirements:

Sulphur content not more than 1.5%
Dry rodded weight AASHTO T 19.....minimum 70 lb/ft³
Glassy Particles.....not more than 10%
Slag shall not be used as an aggregate for Portland cement concrete.

- B. For Air-Cooled Blast Furnace Slag, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T 096) provided that the amount of material finer than No. 200 sieve generated during the Los Angeles Abrasion test is less than 18%.

PART 4 - LIGHTWEIGHT AGGREGATES

4.1 LIGHTWEIGHT COARSE AGGREGATE FOR BITUMINOUS CONSTRUCTION

- A. Lightweight coarse aggregate may be produced from naturally occurring materials such as pumice, scoria and tuff or from expanded clay, shale or slate fired in a rotary kiln. It shall be reasonably uniform in quality and density, and free of deleterious substances as specified in 901-1.2, except that the term cinders and clinkers shall apply to those particles clearly foreign to the extended aggregate in question.

In addition, it must meet the following specific requirements:

Material passing the No. 200 Sieve maximum 3.00%, (FM 1-T 011)
Dry loose weight (AASHTO T 19)*..... 33-55 lb/ft³
Los Angeles Abrasion (FM 1-T 096) maximum 35%
Ferric Oxide (ASTM C 641)..... maximum 1.5 mg

*Source shall maintain dry-loose unit weight within $\pm 6\%$ of Quality Control average. Point of use dry-loose unit weight shall be within $\pm 10\%$ of Source Quality Control average.

4.2 LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE

- A. The requirements of 901-4.1 are modified as follows:

Aggregates shall not be produced from pumice and scoria.
Los Angeles Abrasion (FM 1-T 096, Section 12) shall be 45%, maximum.
Gradation shall meet the requirements of AASHTO M 195 for 3/4 inch, 1/2 inch and 3/8 inch.

PART 5 - RECLAIMED PORTLAND CEMENT CONCRETE

- 5.1 The reclaimed Portland cement concrete shall be from a source which was produced and placed in accordance with applicable Specifications. The material shall be crushed and processed to provide a clean, hard, durable aggregate having a uniform gradation free from adherent coatings, metals, organic matter, base material, joint fillers, and bituminous materials.
- 5.2 The Contractor's (Producer's) crushing operation shall produce an aggregate meeting the applicable gradation requirements. The physical property requirements of 901-1.3 for Soundness shall not apply and the maximum loss as determined by the Los Angeles Abrasion (FM 1-T 096) is changed to 50.
- 5.3 The sources of reclaimed Portland cement concrete will be treated as a mine and subject to the requirements of Section 6 and Section 105.

PART 6 - EXCEPTIONS, ADDITIONS AND RESTRICTIONS

- 6.1 Pertinent specification modifications, based on material usage, will be found in other Sections of the specifications.

SECTION 321130 - SUBGRADE STABILIZATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, apply to work of this Section.

1.2 DESCRIPTION

- A. Stabilize the designated portions of the pavement subgrade in both cut and fill sections to provide a firm and unyielding subgrade to the uniformity, density, bearing value, lines, grades and thicknesses herein specified or shown in the Drawings. The work includes mixing, compacting and grading for a complete job.
- B. Related Work Specified Elsewhere
 - 1. Asphalt Concrete Pavement - Section 321130

PART 2 - MATERIALS

- 2.1 Local Materials: High bearing-soils or sand clay material. The materials passing the #40 mesh sieve shall have a liquid limit not greater than 30, and a plasticity index not greater than 10. Blending materials to meet these requirements will not be permitted unless authorized by the Engineer. When so permitted, the blended material shall be tested and approved before spreading.
- 2.3 Crushed Shell: Mollusk shell, but not steamed shell, (i.e., oysters, mussels, clams, cemented coquina, etc.). Gradation shall be such that at least 97% by weight of the total material passes a 1" sieve, and at least 50% by weight is retained on the #4 sieve. Not more than 20% by weight of the total material shall pass (by washing) the #200 sieve.

PART 3 - EXECUTION

- 3.1 Compaction: Compact the stabilized subgrade in both cuts and fills to a minimum density of 95% of maximum (AASHTO T-180) density. The subgrade shall be shaped to within 1/4 inch of the grades shown in the Drawings.
- 3.2 Maintenance: After the subgrade has been prepared as specified, Contractor shall maintain it free from ruts, depressions and all damage resulting from hauling or handling of any materials, equipment, tools, etc. All work which may become necessary in order to recompact the subgrade shall be at contractor's expense.
- 3.3 Testing: Provide density and bearing value tests at intervals not to exceed 250 feet for roadways or 10,000 square feet for parking areas.

END OF SECTION 321130

SECTION 321216 - ASPHALT CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items necessary for the proper installation of the asphalt concrete paving, as required for the completion of the Work and/or restoration of existing asphalt pavement.
- B. Asphalt concrete paving, includes:
 - 1. Subgrade preparation.
 - 2. Aggregate base.
 - 3. Tack coat.
 - 4. Asphaltic concrete leveling course.
 - 5. Asphaltic concrete surface course.

1.2 DEFINITIONS:

- A. Defective asphaltic paving: Consider defective any portion of the asphalt paving in which creeping, shoving, cracking, raveling, softening or other defects occur during Warranty period. Patch or replace as specified, and as approved by Owner.

1.3 QUALITY ASSURANCE

- A. Reference Specifications and Standards:
 - 1. FDOT (FLORIDA DEPARTMENT OF TRANSPORTATION): Standard Specifications for Road and Bridge Construction.
- B. Tests and inspections:
 - 1. Provide inspecting and monitoring for work specified under Article, "Field Quality Control".
 - 2. In addition to tests and requirements of FDOT, (FDOT- 200-7) conduct a water floods test of critical areas as directed.
 - 3. Completed surfaces: Free of standing water when flood tested. Remove and replace to proper grade with materials in compliance with Specifications.

1.4 SUBMITTALS

- A. Procedures: In accord with Division I.
- B. After award of contract and prior to start of work submit job mix formula, and hot-mix design data sheet, for each type mix used.

1.5 PRODUCT HANDLING

- A. Procedures: In accord with FDOT (FLORIDA DEPARTMENT OF TRANSPORTATION) Specifications.

1.6 SITE CONDITIONS

- A. Weather limitations:

1. Apply bituminous prime coat only when the ambient temperature is 50°F. and rising and when the temperature has not been below 35°F. for 12 hours immediately prior to application.
2. Do not apply when the base surface is wet or contains an excess of moisture which would prevent uniform distribution and the required penetration.
3. Base course may be placed when air temperature is not below 30°F.
4. Construct asphalt concrete surface course only in dry weather when temperature is above 40°F.

- B. Grade control: Establish and maintain the required lines and grades, including crown and cross-slope, for each course during construction operations.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Asphalt concrete: Type SP-12.5 or as noted on Drawings. Conform to 2014 edition of the FDOT Specifications Section 331.
1. Provide plant mixed asphalt concrete in accord with methods and operations requirements of FDOT Sections 320 and 330-1 to 330-6.
- B. Prime coat: Cut-back asphalt, grade RC-70, conforming to FDOT Specifications Section 300.
- C. Tack coat: Asphalt emulsion (SS-1H) or (RS-2) grade conforming to FDOT Specifications Section 300.
- D. Seal coat: Seal coat is not required.

PART 3 - EXECUTION

3.1 INSPECTION AND PREPARATION

- A. Examine all surfaces over which asphalt is to be applied.
1. Insure that no defects, low sections, depressions or holes are present which would jeopardize the standard of finish specified.
- B. Proof roll subgrade using heavy, rubber-tired rollers. Check for unstable areas. Check for areas requiring additional compaction or replacement.

3.2 STABILIZATION OF SUBGRADE

- A. Areas designated to be paved or to be restored to their preconstruction condition and having a soil-cement base shall be stabilized as indicated on the drawings to the depth shown from the grades indicated in accord with FDOT Standard Specification Section 160.

3.3 AGGREGATE BASE COURSE

- A. Minimum compacted thickness: 8 inch or as indicated on Drawings.
- B. Spread soil-cement in accordance with FDOT Standard Specifications Sections 200-4, 200-5.1 and 200-5.2.
- C. Compaction of soil-cement shall be accomplished in conformance with Section 200-6 of the FDOT Standard Specifications.

3.4 PRIMING AND MAINTAINING

- A. Priming: The prime coat shall be applied only when the base meets the specified density requirements and the moisture content in the top half of the base does not exceed 90 percent of the optimum moisture of the base material. At the time of priming, the base shall be firm, unyielding and in such condition that no undue distortion will occur.
- B. Maintaining: The Contractor will be responsible for assuring that the true crown and templet are maintained, with no rutting or other distortion, and that the base meets all the requirements, at the time the surface course is applied.

3.5 TACK COAT

- A. When new asphalt is to be placed against existing or new concrete or asphalt surfaces, such as curbs, gutters, walls, structures, or other paving, coat such surfaces with a tack coat of asphaltic emulsion before the new paving is placed.
- B. Apply tack coat by fogging method; no exceptions allowed.

3.6 ASPHALT CONCRETE

- A. Provide transportation, placing and compacting of asphalt concrete, preparation of application surfaces, joints, tolerances and protection of the finished asphalt in accord with FDOT Section 330.
 - 1. Refer to Division I for testing.
- B. Spread asphaltic concrete from a slow moving spreading machine to assure that mix is properly tamped.
 - 1. Roll asphaltic concrete surface source with single pass while material is over 185°F.

- C. Spread asphaltic concrete in such a manner as to assure that transverse joints created by stopping and restarting paving equipment will be smooth and cause no objectionable visual defects or perceptible interruption that would be detected in a normal ride over the surface.

3.7 PATCHING

- A. Remove and replace defective areas.
- B. Cut-out and fill with fresh, hot asphalt concrete.
- C. Compact by rolling to specified surface density and smoothness.
- D. Remove deficient areas for full depth of course.
- E. Cut sides perpendicular and parallel to direction of traffic with edges vertical.
- F. Apply tack coat to exposed surfaces before placing new asphalt concrete mixture.

3.8 FIELD QUALITY CONTROL

- A. Receive approval from Engineer, prior to starting of Work, of all paving equipment:
 - 1. Paving equipment to be in accord with submittals furnished.
 - 2. Correct all deficiencies in equipment not meeting manufacturer's specifications prior to starting Work.
- B. Provide Engineer with certified evidence, prior to starting work, that source of material, job mix formula, and hot mix design is in accord with submittals furnished.
- C. Verify that all paving equipment is cleaned, in accord with equipment manufacturer's recommendations, at the end of each days paving operations.
- D. Material testing engineer or technician to visually observe and monitor placement and construction of soil-cement base material. Surface of the soil-cement shall be tested per FDOT Standard Specification Section 200-7.
 - 1. Verify that depth of base course meets or exceeds Work specifications.
- E. Material testing engineer to perform the following:
 - 1. Visual observations of uniformity and moisture condition of base material at arrival on site.
 - 2. Random depth checks both before and after final compaction to assure minimum compacted thickness as shown on the Drawings.
 - 3. Field density tests to assure uniform and satisfactory compaction in excess of 98% Maximum Density Value.

3.9 CLEANING AND PROTECTION

- A. Cleaning: After completion of paving operations, clean surfaces of excess or spilled asphalt materials. The cleaning process used may include sand blasting or other methods at the direction of the Owner. This work shall be at no additional cost to the Owner.
- B. Protection: After final rolling, do not permit vehicular traffic on asphalt concrete pavement until it has cooled and hardened, and in no case sooner than as permitted by FDOT Section 330.

END OF SECTION 321216

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SECTION 321316 - DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes exterior integrally colored, stamped, and sealed concrete paving.
- B. Related Sections:
 - 1. Section 079200 "Joint Sealants" for sealants within expansion joints to match decorative concrete paving.
 - 2. Section 321313 "Concrete Paving" for cast-in-place concrete paving mix design, concrete with other finishes, walks, curbs, and gutters.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples for Verification: For each type of exposed color, pattern, or texture indicated.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.
- B. Source Limitations: Obtain decorative concrete paving products of the same brand from same manufacturer.
- C. 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.
- D. 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. Quality control of concrete materials and decorative concrete paving construction practices.
 - b. Application process for penetrating concrete stain and sealer.
 - c. Protection procedures for completed work.
 - 2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Decorative concrete paving Installer.
 - c. Manufacturer's representative of decorative concrete paving system.

1.7 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

1.8 CURING AND SEALING MATERIALS

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of silane/siloxane water repellent.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide CHEMSTOP WB Regular as manufactured by The Euclid Company or comparable products by one of the following:
 - a. Meadows, W. R., Inc.
 - b. Scofield, L. M. Company

1.9 DECORATIVE FINISH

- A. Standard Gray Concrete with a medium broom finish with commercial grade, high traffic, non-slip paint applied to the surface. Two coats minimum shall be applied with each coat being allowed to dry for a minimum of 48 hours before the next coat is applied. Minimum 72 hours shall be provided after all paint coats have been applied before any foot traffic is allowed on the walk. Paint colors shall be vibrant colors matching the colors represented on the site plan rendering.
- B. Standard Gray Concrete with a medium broom finish with commercial grade, high traffic, non-slip penetrating stain applied to the surface. Two coats minimum shall be applied with each coat being allowed to dry for a minimum of 48 hours before the next coat is applied. Minimum 72 hours shall be provided after all stain coats have been applied before any foot traffic is allowed on

the walk. Stain colors shall be vibrant color matches to the colors represented on the site plan.

- a. Stain Colors:
 - i. See hardscape plans, interior color designations and site plan rendering for color locations.

- C. Integral Color Stamped Concrete with a custom stamped finish applied to the surface.
 - a. Concrete shall be stamped with flexible mat to match interior stamped concrete.

1.10 EXAMINATION

- A. Examine concrete to verify acceptability of surface.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

1.11 PREPARATION

- A. Protect adjacent construction from discoloration and spillage during application of color hardeners and sealers.

1.12 CURING

- A. Concrete shall be cured per Section 32 1313 "Concrete Paving."

1.13 SEALER

- A. Prepare dry, cured concrete surfaces per manufacturer's written instructions.
- B. Apply penetrating sealer uniformly per manufacturer's written instructions.

1.14 REPAIRS AND PROTECTION

- A. The Contractor is responsible for using temporary protection throughout the Project to safeguard the surface quality of concrete slabs before and after application of decorative finishes or installation of other materials.
 - 1. All exterior concrete shall be protected throughout the Project.
- B. 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.
- C. 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.

END OF SECTION

SECTION 321600 - CURBS, GUTTERS, SIDEWALKS, AND DRIVEWAYS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items necessary for the proper installation of the site concrete.
- B. Site concrete work includes:
 - 1. Subgrade preparation.
 - 2. Concrete pavement, equipment pads and housing pads.
 - 3. Meandering concrete footpath, walkways and joints
 - 4. Concrete curbs and, gutters
 - 5. Light pole bases, complete with anchor bolts, leveling nuts and grout
 - 6. Reinforcing steel.
 - 7. Concrete work associated with Site and street furnishings
 - 8. Concrete utilities structures (catch basins, manholes, Inlet structures, junction Boxes, switching stations and similar.), and grout base /fillets.
 - 9. Post footings (concrete only), for Fences, Signage and miscellaneous items (thrust blocks, isolated pipe supports etc.)
 - 10. Built-in bolts, anchors, frames and all other embedments.

1.2 QUALITY ASSURANCE

- A Reference Specifications and Standards:
 - ACI: 305 Hot Weather Concreting.
 - ACI: 306 Recommended Practice for Cold Weather Concreting.
- B Allowable tolerances: 1/8 inch in 10 feet in any direction.
- C. Site mock-ups
 - 1. Provide for approval, a 4 feet x 4 feet x 4 inches thick minimum job site cast and finished sample panel for each type concrete finish. Cure samples as specified.
 - a. Include in each panel, all joint types which will occur in each type finish work.
 - 2. Cast samples on grade at locations as directed by Owner/Engineer.
 - 3. If first samples are not approved, prepare additional samples until approval is obtained.
 - 4. Sample panels will be used to judge final finish work.
 - 5. Protect samples during course of work, remove then when directed to do so by Owner/Engineer.
- D. Provide concrete test cylinders. Monitor slump and 28 day compressive strength. Samples to be taken at a rate of one per four cubic yards of concrete.

1.3 SITE CONDITIONS

A. Weather limitations:

1. Do not place concrete when the atmospheric temperature is as low as 35°F or expected to go below that temperature within 24 hours.
2. Do not place concrete during any rain that will cause surface damage to the concrete.
3. Hot weather concreting: In accordance with ACI 305.
4. Cold weather concreting: In accordance with ACI 306.

B. Traffic control:

1. Maintain vehicular and pedestrian traffic control during concrete operations.
2. Provide flagmen, barricades, warning signs, and warning lights for movement of traffic and safety, and to cause the least interruption of work.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Concrete: Minimum acceptable Concrete Compressive Strength shall be as indicated on the Drawing.
- B. Formwork and finishing: Shall be in accordance with local building code regulations
- C. Reinforcement: Shall be in accordance with local building code regulations: Reinforcing Steel.
- D. Joint materials:
1. Expansion joint filler: In accordance with FDOT Specifications Section 932-1.1, Preformed Joint Filler for Pavement and Structures.
 2. Expansion joint sealant: In accordance with FDOT Specifications Section 932-1.2, Joint Sealer for Pavement and Structures.
- E. Liquid bonding agent:
1. Weld-crete by Larsen Products Corp.
 2. Lambco Latex 460 by Lambert Corp.
 3. Hornweld, by A.C. Horn, Inc.
 4. Sonocrete, by Sonneborn Building Products.
- F. Curing and protection paper: Sisalkraft Orange Label, by Sisalkraft Division, St. Regis Paper Co., or equivalent which complies with ASTM C171.
1. Where concrete will be exposed and be subjected to abrasion, such as floor slabs, use non-staining paper equivalent to Sisalkraft "Seekure 896", or other reinforced paper faced with polyethylene film.
- G. Liquid Curing agents:

1. Curing compound:
 - a. West Chemical Floor Treatment by West Chemical Products, Inc.
 - b. Horncure 30C by A.C. Horn, Inc.
 - c. Hunt Process TLF by Hunt Process Co., Inc.
 - d. Lambco 64B by Lambert Corp.
 - e. Hydrocide Curing Compound by Sonneborn Building Products.
2. Combination curing and hardening compound.
 - a. Ashford Formula by U.S. Permaseal Inc.
 - b. West Chemical Floor Treatment by West Chemical Products, Inc.
 - c. Horn Clean Seal by A.C. Horn, Inc.
 - d. Sika Cure/Hard by Sika Chemical Co.
 - e. Crystal Clear Seal (interior) Crystal Gard Seal (Exterior by Lambert Corp.
 - f. Kure-N-Seal by Sonneborn Building Products.
3. Chemical for hardener - fluosilicate type - delayed application:
 - a. Ashford Formula by U.S. Permaseal Inc.
 - b. Lapidolith by Sonneborn, Division of Contech, Inc.
 - c. Saniseal by Master Builders Co.
 - d. Permalith by L.M. Scofield Co.
 - e. Solidus by Lambert Corp.
 - f. Hornolith by A.C. Horn, Inc.
- H. Slip resistant abrasive aggregate: Aluminum oxide, 14/36 grading, manufactured by:
 1. Carborundum Company.
 2. Norton Company.
 3. A-H Products, Division of Anti-Hydro Waterproofing Company.
 4. L.M. Scofield Company.
 5. Burke Concrete Accessories, Inc.
- I. Integral mineral coloring pigments:
 1. L.M. Scofield Company, "Chromix".
 2. Davis, Colors.
 3. Lambert Corporation, Colors.
 4. Landers - Segal Color Company, Inc.
- J. Curing materials for non colored concrete: In accord with FDOT Specifications Section 925, Curing Materials for Concrete.
- K. Borrow material (for fill): Clean earth and granular material free of roots and organic materials, not more than 10 percent passing a No. 200 sieve. No rocks or lumps larger than 6 inches in any dimension will be permitted.
- L. Extra Heavy-Duty, Processed Iron Aggregate Topping

1. Anvil-Top 300" manufactured by Master Builders, processed size graded aggregate, (not a naturally occurring mineral aggregate), cement, and technical components, necessary to produce screedable, metallic floor topping. Manufacturer shall certify he has a minimum of 20 years' experience in manufacturing iron aggregate floor toppings, and can document success. Material shall be ready to use and require only addition of water at jobsite, shall be sealed in moisture resistant 55 lbs. (25kg) bags, or 3,300 lb. (1497 kg) bulk bags. Material shall be formulated and processed under stringent quality control, free from non-ferrous particles rust and material intended to disguise rust.
2. Material shall be applied at the rate of 18.0 lb/sq. ft. (87.8 kg./m²) for specified 1" thickness (25mm), in accordance with the manufacturer's installation instruction applied over concrete properly roughened and bonded or over fresh, plastic concrete. (Under no circumstances should less than a 1/2" (13mm) thickness be used).
3. Curing Material for topping shall be "Masterseal W," manufactured by Master Builders, shall exceed moisture retention requirements of ASTM-C 309-81, when used at a rate of coverage recommended by the manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE

- A. Compaction: Compact top 12 inches subgrade to 95% maximum density in accordance with ASTM D3017 (Nuclear method), or ASTM D1557 Method A (5-layer method).
- B. Do not allow traffic over prepared subgrade.
- C. Uniformly moisten subgrade at time concrete is placed. Uniformly apply water ahead of concrete placement.
- D. Accurately trim to required elevations.
- E. Allow for full thickness concrete.

3.2 SITE STRUCTURES

- A. Construct catch basins, manhole bases, junction boxes, inlets, and other similar site structures to conform to requirements of FDOT SPECIFICATIONS Section 425, Inlets, Manholes and Junction Boxes.

3.3 JOINTS

- A. Pour joints:
 1. Construct pour joints (construction joints) at any break in concrete placement lasting more than 1 hour.
 2. Construct pour joints as indicated at color changes.
 3. Except at expansion joints, key pour joints.
- B. Expansion joints:

1. Construct expansion joints at locations indicated.
 2. Seal expansion joints with sealer as specified.
- C. Control joints:
1. Construct control joints (contraction joints) at locations indicated.
 2. Pour joints may be substituted for control joints at Contractor's option.

3.4 CURING FORMED SURFACES

- A. Commence curing formed concrete surfaces with water as quickly as formwork is loosened or removed.
- B. Thoroughly saturate concrete surfaces and maintain them uniformly wet for a period of not less than 14 days after concrete has been placed.
1. During the curing period, soak the surfaces as often as necessary to maintain thoroughly saturated condition.
 2. It is mandatory that water curing be continued as a case of emergency during holidays and weekends.

3.5 FINISHING FORMED SURFACES

- A. Finish all surfaces of formed concrete which will remain exposed in the finish work, both interior and exterior, including surfaces which will be painted. Provide surfaces uniform for the intended texture; free from imperfect joints, fins, "honeycombing", air pockets or "bug" holes, or other such imperfections.
- B. Remove rough spots, stains and hardened mortar or grout from intended smooth surfaces by rubbing such surfaces lightly with fine carborundum stone. Use liberal amounts of water and rub sufficiently to remove defects without changing texture of concrete.
- C. If intended smooth surfaces are not of uniform texture, treat as follows.
1. Prepare a mix consisting of one-part portland cement, 1-1/2 parts fine sand, and sufficient water to produce a grout of the consistency of thick paint.
 2. Wet surface to be treated and apply grout uniformly with a brush, completely filling air holes. Immediately float, scouring the surface vigorously. Allow cement grout to partially set for an hour or two depending on weather.
 3. When grout has sufficiently hardened so it can be scraped from surface with the edge of a steel trowel without removing grout from small air holes, cut-off all that can be removed with a trowel, allow surface to dry thoroughly, then rub vigorously with burlap to completely remove surplus.
 4. Further finish exposed intended smooth surfaces, if necessary, by means of honing with a carborundum stone to uniform surfaces as directed by Owner.
 5. Complete entire operation of any area the day it is started.
 6. Do not use dry cement sacking.

3.6 FINISHING AND CURING FLAT WORK

A. Finishing:

1. Tamp freshly placed concrete with approved metal grid tampers not less than 12 inches x 12 inches in size so as to bring fines to top, then rod to uniform surfaces at required levels.
 - a. Float and trowel finish as soon as surface becomes workable.
 - b. Provide slopes as indicated on Drawings, or as directed by Owner.
2. Provide fog-spray equipment for use during finishing to maintain adequate surface moisture and reduce plastic shrinkage.
 - a. Immediately after fresh concrete has been brought to a flat surface, a shiny film of moisture will appear on top. As soon as the shiny surface disappears, it must be restored and maintained until troweling, by providing a light film of moisture with an atomizing type fog-sprayer.
 - b. Use frequent light applications of moisture rather than excessive wetting. Temperature, humidity and wind conditions will dictate the amount of spray required for proper control.
3. Work and measure concrete flatwork until it is level to within 1/8 inch in 10 feet in any direction.

B. Surface finish textures:

1. Brush or broom finish: Use for inclined ramps, and all other exterior locations.
 - a. Apply color pigment uniformly and at a rate to achieve the color selected and approved by Owner. Apply in accordance with pigment manufacturer's instructions.
 - b. Apply sealer over finished surfaces in accordance with manufacturer's instructions.
 - c. The brush or broom finish is achieved by drawing a push broom across the still plastic surface to create uniform striations.
 - d. In some instances, if directed by Owner, striations may be zig-zag type.
 - e. In some instances, if directed by Owner, create texture striations by use of a stiff fiber bristle broom.

C. Curing:

1. Cure flat slabs with combination curing and hardening compounds.
 - a. Apply compound in accordance with manufacturer's recommendations immediately following final finishing operations.
2. Cure all concrete not otherwise specified, with liquid curing compound.
 - a. Caution: Some waterproofing materials are not compatible with some curing compounds. Verify compatibility of materials before curing concrete slabs which will receive direct applied waterproofing.

3.7 EXTRA HEAVY-DUTY TOPPING

A. Application of Extra Heavy-Duty, Iron Aggregate Topping

1. Manufacturer's representative shall be present during initial stages of installation. Installer shall consult with manufacturer's representative during bidding and prior to installation on correct use of the product. Deviation from the manufacturer's recommendations will be responsible of the installer.

Minimum Slump	-	not less than 5" (127 mm).
Maximum Slump	-	not to exceed 7" (178 mm).

B. Surface Preparation: Mixing and Placing of Topping

1. Preparation of base concrete, mixing of materials and application of the topping shall be in strict accordance with manufacturer's procedures, as indicated in current product data and direction sheets and/or as described by manufacturer's rep. DO NOT OVER FINISH.

C. Curing and Protection

1. WET CURE FOR MIN. OF 48 HOURS, PRIOR TO APPLYING CURING COMPOUND.
2. Concrete finished with Anvil-Top 300, processed iron aggregate topping, shall be cured with Masterseal W, in accordance with manufacturer's recommendations. Manufacturer of the iron aggregate topping shall provide, at no cost, services of a trained, full-time employee, during periods of critical installation. A minimum of three (3) days' notice shall be given by the contractor, to the manufacturer, prior to initial use of the product.

END OF SECTION 034701

SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract apply to work of this Section 321216.

1.2 DESCRIPTION OF WORK

- A. Pavement markings.
 - 1. Provide marking paint for perimeter and marking outside traffic flow patterns or in areas where existing markings have been disturbed.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- A. Asphalt concrete paving - Section 321216

1.4 SUBMITTALS

- A. Procedure: Submit in accord with General Conditions.
- B. Product data: Submit manufacturer's detailed literature.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Pavement Marking Paint
 - 1. Conform to the requirements of FDOT Specifications Section 971.
 - 2. Color
 - 3. White - Code T1
 - 4. Yellow - Code T2
 - 5. Acceptable
 - a. Tnemec's Traffic Paint
 - b. Glidden-Durkee's Romark Traffic
 - c. PPG's Traffic and Zone Marking
- B. Thermoplastic Compound
 - 1. Conform to the requirements of FDOT Specifications Section 711

PART 3 - EXECUTION

3.1 PAINT MARKINGS APPLICATION

- A. Obtain approval of marking layouts prior to paint application.
- B. Traffic line markings: 4 inches wide unless otherwise indicated.
- C. Machine apply in strict accord with recommendations of paint manufacturer.
- D. Apply two coats or more as required for complete opacity.
 - 1. Apply first coat after all paved surfaces to be painted are dry and cured for a minimum of 48 hours.
 - 2. Apply second or final coat prior to completion of project.
- E. Paint directional lettering, arrows and other markings by similar methods with same paint. Use stencils and masking tape as required to achieve required designs.

END OF SECTION 321723

SECTION 321816 - PLAYGROUND CUSHIONED SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Cushioned Synthetic Turf Surface System.
 - 2. Poured-in-place Cushioned Rubber Surface System.
 - 3. Geosynthetic soil separation fabric.

- B. Related Sections:

- 1. Section 312000 "Earth Moving" for filling and grading and for drainage course, drainage/separation geotextiles and subbase course.
 - 2. Section 116800 Playground Equipment.
 - 3. Section 322200 Synthetic Turf Base.

1.3 DEFINITIONS

- A. Critical Fall Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
- B. SBR: Styrene-butadiene rubber.

1.4 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: According to ASTM F 1292.
- B. Accessibility of Surface Systems: According to ASTM F 1951.
- C. Minimum Characteristics for Organic Loose-Fill Surfaces: According to ASTM F 2075.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each playground surface system, include materials, plans, cross sections, drainage, installation, penetration details, and edge termination. Include patterns made by varying colors of turf surfacing per Drawings.
- C. Samples for Initial Selection: For each type of playground surface system indicated.
 - 1. Include similar Samples of playground surface system and accessories involving color selection.
- D. Samples for Verification: For each type of playground surface system indicated.
 - 1. Minimum 6-by-6-inch (150-by-150-mm) sample of synthetic turf surface.
 - 2. Minimum 6-by-6-inch (150-by-150-mm) sample of playground pad and seaming system.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Extent of surface systems and use zones for equipment.
 - 2. Critical heights for playground surfaces and fall heights for equipment.
 - 3. Data certifying cushioned systems being provided comply with critical fall zone requirements.
- B. Qualification Data: For qualified Installer and testing agency.
- C. Material Certificates: For turf and cushioned pad playground surface system, from manufacturer.
- D. Material Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for playground surface system.
- E. Product Certificates: For synthetic playground surface system, from manufacturer.
- F. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each synthetic turf playground surface system.
- G. Field quality-control reports.
- H. Warranty: Sample of special warranty.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain playground surface system materials from single source from single manufacturer.
 - 1. Provide secondary materials including adhesives, seaming tape, geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.
- C. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292; and ASTM F 1487.

1.8 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit playground surface system installation to be performed according to manufacturers' written instructions and warranty requirements.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fails in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Reduction in impact attenuation.
 - b. Deterioration of surface, base foam pad, and other materials beyond normal weathering.
 - c. Delamination of turf from backing material or failure of turf or thatch zone.
 - 2. Warranty Period: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYNTHETIC TURF GRASS SURFACE

- A. Surfacing System Basis of Design: Synthetic Polyethylene turf grass system. Provide manufacturer's standard thickness as required for overall thickness indicated, tested for impact attenuation.
 - 1. Products: Subject to compliance with requirements, provide the following or approved equal:

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- a. Forever Lawn premium play grass system: "Fusion".
2. Cushioned Pad:
 - a. Product: Subject to compliance with requirements, provide the following, or approved equal:
 - 1) Schmitz; ProPlay permeable cushioned fall zone safety attenuation pad.
3. Turf (grass zone): Nylon.
4. Turf (thatch zone) Texturized Nylon.
5. Pile height Grass: 1-1/2-inch grass and thatch zone are 1-1/4-inch height.
6. Total Pile Weight: 53 oz. for Grass and 27oz. for Thatch with Total Pile weight = 80oz. per ASTM D 5848.
7. Product shall have a primary and secondary backing weight of 27 oz./SY. Tuft gauge of 3/8-inch. Tuft bind shall exceed 8 lbs. Flammability rating shall meet ASTM D 2859 and ASTM E 648. Water permeability shall exceed 30-inches per hour. Per ASTM F 1551.
8. Cushioned Pad: Product to be a 3-inch minimum thickness with 98% recycled, non-contaminated, post-industrial, cross-link, and closed cell polyethylene foam. Tensile strength of 34-36 PSI per ASTM 3574. Hydraulic behavior shall meet transmissivity requirements per ASTM 4746 and Permeability of 36 gallons/minute/SF per ASTM D 2474. Includes geotextile on top side of pad to prevent weed growth.
9. Critical Fall Height: Provide cushion system for 8-feet (2.4 m) critical fall height or as indicated.
10. Overall Pad Thickness: Not less than as required for critical height indicated or 2-inches (50 mm) minimum.
11. Adhesive/Seaming Tape: Manufacturer's standard adhesive and seaming tape that is porous, weather-resistant, adhesive suitable for stabilizing cushioned foam pad underlayment.
12. Turf Fiber Color: Field Green and Lime Green blend or as selected by Architect from manufacturer's full range.
13. Thatch Zone Color: Tan.

2.2 POURED-IN-PLACE RUBBER BONDED SEAMLESS SURFACING SYSTEM

- A. Surfacing System Basis of Design: Provide DuraPlay Inc. poured-in-place, seamless rubber surfacing system meeting or exceeding CPSC guidelines for ASTM F1292 and for accessibility according to ASTM F1951. Install manufacturer's recommended surfacing thickness to accommodate an 8-feet fall height or 3-inch minimum thickness, tested for impact attenuation.
 1. Composition: Blend of recycled SBR and EPDM rubber, particles and binder, forming a wearing and cushioning product.
 2. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane.
 3. Critical Height: 8 feet (2.4 m).
 4. Overall Thickness: Not less than as required for critical height indicated 3 inches (75 mm) as indicated on Drawings.

5. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
 6. Lacquer Topcoat: Manufacturer's standard polyurethane-based formulation.
 7. Wearing Layer Color(s): As indicated on the Drawings and as selected by Architect from manufacturer's full range. Provide blend of 50 percent color and 50 percent "black" in surface layer to produce colors as shown on the Drawings.
- B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.3 GEOSYNTHETICS

- A. Drainage/Separation Geotextile Fabric: Nonwoven, needle-punched geotextile, manufactured for subsurface drainage applications and made from polyolefins or polyesters. Complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
1. Weight: 4 oz./sq. yd. (136 g/sq. m) according to ASTM D 5261.
 2. Water Flow Rate: 100 GPM/sq. ft. (68 L/s per sq. m) according to ASTM D 4491.

END OF SECTION 321816.13

SECTION 321819 – COURT SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Acrylic color play court surfacing for hard play games as shown on the Documents.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, and plan showing dimensions of court games.
- B. Provide at least five projects where the Contractor has installed this type of acrylic court surfacing system. The installer shall be approved by the material supplier to install the court surfacing system. Provide reference projects, name, and contact phone number for representative tennis court installations. If the installer has installed less than three courts with the specified material, the material manufacturer shall have a representative on the site that has had experience in the installation of the type of court surfacing specified.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Material Certificates: Color surfacing and acrylic fill materials, signed by manufacturers for each type of product indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Court Surfacing:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:
 - a. Nova Sports USA.

- b. Plexipave.
- c. Sports Coatings.
- d. Approved equal manufacturer.

2.2 COURT SURFACE

A. Description:

1. Application of color surfacing system for concrete or asphalt courts.
 - a. Repair minor depressions and other defects before application of the color surfacing system.

B. Materials:

1. Asphalt emulsion.
2. Patch binder.
3. Primer.
4. Acrylic filler.
5. Asphalt filler.
6. Color concentrate.
7. Line paint.

C. Application:

1. Surface Preparation:
 - a. Cure asphalt pavement 14 to 21 days prior to applying any coating application.
 - b. Thoroughly clean surface with compressed air and remove any oil, grease, dirt, or other foreign matter.
 - c. Flood surface with water and mark all depressions greater than the thickness of a nickel after one hour of drainage.
2. Depression Repair:
 - a. Fill marked depressions with patching mix of either acrylic fill or patch bind.
 - 1) If using asphalt fill, scrub area clean and tack with solution of one-part asphalt emulsion and five parts water.
 - 2) To fill depressions, use the following formulation:
 - a) Asphalt Fill: 10 gallons.
 - b) Silica Sand (40-70 Mesh): 100-120 lbs.
 - c) Portland Cement: 1/2 gallon.
 - b. If using acrylic fill, scrub area clean and tack with primer or a solution of one-part acrylic fill and two parts water. To fill depressions, use the following formulation:

- 1) Acrylic Fill: 10 gallons.
 - 2) Silica Sand (40-70 Mesh): 140-240 lbs.
 - 3) Portland Cement: 1/2 gallon.
3. Prime Coat: Apply one coat of diluted asphalt emulsion or primer to especially dirty or oxidized asphalt surfaces. Dilute one-part asphalt emulsion with five parts water and broom on the surface. Apply at least the first coat of resurfacer the same day. Do not dilute primer.
4. Leveling Coats: If acrylic fill is used, use the following formulation:
 - a. Acrylic Fill: 53 gallons.
 - b. Silica Sand (40-70 Mesh): 636-742 lbs.
 - c. Water: 32-37 gallons.
5. Color Coats:
 - a. Apply two coats of color concentrate with a coverage rating of 0.05 gallons per square yard for each coat, using the following formulation:
 - 1) Color Concentrate: 53 gallons.
 - 2) Silica Sand (60-90 Mesh): 318-424 lbs.
 - 3) Water: 26-32 gallons.
 - b. Do not leave ridges. Apply second coat only after the first coat is completely dry.
 - c. Colors: Refer to Drawings. Colors will be selected from manufacturer's full color range.
6. Court Lines:
 - a. Apply coat of line sharp between masking tape to prevent bleeding of line paint under tape. Once dry, apply line paint for a crisp, clean line.
7. Weather Limitations: Do not apply surfacing system if temperature is below 50 deg F or if freezing temperatures are forecast for the next 24-hour period. Do not apply on a wet surface or when rain is forecast for the next 24-hour period. Ensure that products do not freeze.

END OF SECTION 321819

SECTION 32 3119 - DECORATIVE METAL FENCES AND GATES

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. All fencing is delegated design including all member sizing, reinforcement, footing and foundations, etc. This Section includes the following (refer to site plans for the following fence types):
 - 1. Site Security: Provide 8-foot height ornamental welded wire fence and gates with one tension strand of barbed wire Equal to Omega II Fencing: provide "Omega MAX" high security fence and gates system. Provide with powder coat finish. Color: "Black".
 - 2. Interior Fencing: Provide Ameristar Montage Plus 8-foot height, 3-rail, ornamental picket fence and gates or approved equal. Provide with powder coat finish. Color: "Black".
 - 3. Pool Fencing: Provide Ameristar Montage Plus 6-foot height, 3-rail, ornamental picket fence and gates or approved equal. Provide with powder coat finish. Color: "Black".
 - 4. Playground Fencing: Provide Ameristar Montage Plus 4-foot height, 3-rail, ornamental picket fence and gates or approved equal. Provide with powder coat finish. Color: "Black".
 - 5. Interior Guard Rails: Provide 42-inch height decorative punched metal infill panels with perimeter frame and posts at 6-feet o.c. Provide with powder coat finish. Color: "Silver".

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide decorative metal fences and gates, including foundations, capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Line Post Design: Provide line posts in size and at spacing indicated but not less than sizes and spacings required to comply with CLFMI WLG 2445 in resisting the following wind-load criteria, based on fence height, cladding, and pattern indicated:
 - a. Design Wind Loads: Determine design wind loads applicable to Project from basic wind speed and exposure category as indicated on Structural Sheet S0.1.

1.4 SUBMITTALS

- A. Shop drawings detailing fabrication and erection of each metal fabrication indicated. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
 - 1. Where installed metal fabrications are indicated to comply with certain design loadings, include structural computations, material properties, and other information needed for structural analysis that has been signed and sealed by the qualified professional engineer who was responsible for the preparation.

- B. Delegated-Design Submittal: For decorative metal fence assemblies indicated to comply with performance requirements and design criteria, including analysis data, foundation and anchorage design signed and sealed, by the qualified professional engineer responsible for their preparation, licensed in the state in which the project occurs.
- C. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" Article.

1.5 MATERIALS

- A. Line Posts: HSS members as specified in Section 051200 "Structural Steel Framing."
- B. Metal Cladding Panels: As specified in Section 074213 "Metal Wall and Soffit Panels."

1.6 GATES

- A. Gates shall be located as shown on the Drawings and sized to suit existing walkways and roadways. All vehicular gates shall have a minimum clear opening of 20 feet to permit Fire Department access. Materials used shall be equal to or greater than that used in adjoining sections of fence and be compatible with the application.

1.7 PEDESTRIAN GATES

- A. Pedestrian gates shall have a ladder type frame, i.e., two vertical ends and two horizontal rails made of 2" square steel tubing, and a slide bar. Provision shall be made to prevent the gate from being lifted off the hinges.

1.8 HINGING

- A. All swinging gates are to have ball bearing barrel hinges, with stainless steel hinge pins and bearings by Magnum Engineering or approved equal. All hinges shall have a zerk fitting for greasing. Hinge sizes as follows:
 - 1. Pedestrian Swing Gate - 5" x 1-1/4" (2 per leaf)
 - 2. Oversize Pedestrian Gate - 7-1/2" x 1-1/2" (3 per leaf)

1.9 LOCKING AND STOPS

- A. All gates shall have a slide bar for locking by use of a padlock and a 'Knox' padlock for fire department access. Gate assemblies shall not require use of chains to secure the gate.
- B. All gate drop rod assemblies are to use a 1/2" diameter solid steel center stop. Provide a 6" steel sleeve. In asphalt areas secure sleeve in a 6" diameter by 18" deep concrete footing.
- C. All vehicular and fire lane gates shall have a hold open post. Posts shall have a provision for locking the gate to the post in the open position.

1.10 PERFORMANCE REQUIREMENTS

- A. All fencing and gates shall be designed and constructed to withstand the weight of a 200-pound person standing at the mid-point on the lower rail without permanent deformation of any component members of the assembly.

1.11 FINISHES AND PAINTING

- A. Contractor to provide fencing and gates with manufacturer's standard baked powder coat system. Color: "Silver" or approved equal from manufacturer's full range of colors.
- B. Refer to Division 09 Section "High-Performance Coatings" for exterior finish system if powder coat finishes are not available.
 - 1. Hot dip galvanization shall be applied by the manufacturer.
- C. Primer: Fabricator's standard lead- and chromate-free nonasphaltic, rust inhibiting primer.

1.12 ON THE JOB SITE

- A. After the fence has been erected and is mechanically complete, wire brush field welds, dry wipe off all loose residue, spot prime with primer specified above all bare metal, bare spots and chips, and unpainted surfaces. Then spray a finish coat layer over the entire fence installation with one coat of high-performance paint specified in Division 09 Section "High-Performance Coatings." Care shall be taken to keep paint off of sidewalks, walls, and other site elements. The Contractor shall completely remove any spilled paint from site objects to satisfaction of the Architect.

1.13 FABRICATION AND INSTALLATION

- A. Gates shall be welded and have smooth, clean, slag free welds. Dimensions and installation shall be in accordance with the Detail Print which is part of this specification.

1.14 POST SETTING

- A. All posts to be set in concrete as follows:

<u>Diameter</u>	<u>Depth</u>	<u>Embedment</u>	<u>Post</u>
12"	48"	42"	Line
As detailed	As detailed	42"	Terminal, Corner, Gate
As detailed	As detailed	As detailed	6" Gate Post

- B. All posts to have concrete domed to shed water. All posts to be set to a maximum of 8 feet o.c. All posts to be set plumb, in line, and to correct height. A Corner Post is required when line of fence direction changes 30 degrees or more.
- C. All posts set in existing concrete slabs to be set in a 6-inch core drilled hole and set to a depth of 24 inches. All 6-inch gate posts set in existing concrete slabs are to be set in 12-inch square saw cut to a depth of 43 inches.

1.15 SITE CLEAN UP

- A. The construction site shall be cleaned up and all accumulated debris removed by the Contractor.

END OF SECTION

SECTION 323300 - SITE FURNISHINGS

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. Seating.
- B. Related Requirements:
 - 1. Section 034500 "Precast Architectural Concrete" for installing anchor bolts pre-drilled into concrete wall per manufacturer recommendations.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
- B. Material Certificates: For site furnishings manufactured with preservative-treated wood.
 - 1. Indicate type of preservative used and net amount of preservative retained.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For site furnishings to include in maintenance manuals.

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. Bench Replacement Planks: No fewer than two full-size units for each size indicated.
 - 2. Anchors: ½-inch Stainless Steel concrete hex bolt with washer as recommended by the seating manufacturer. Provide four extra fasteners and washers.
 - 3. Wood Protection: Provide two one-quart containers of Cutek Extreme Wood Protection Oil as recommended by manufacturer.

PART 2 - PRODUCTS

2.1 WALL MOUNT BENCH

- A. Basis of Design: Provide Landscape Forms “Link” bench, inline straight armless and backless front wall mount bench at 23.5-inch depth by 87.5-inch length with powder-coated frame finish or approved equal.
- B. Frame: Steel.
- C. Seat:
 - 1. Material:
 - a. Wood: Ipe wood Class 1 wood in natural color; formed into evenly spaced parallel planks.
 - 2. Seat Height: As indicated.
 - 3. Seat Surface Shape: Flat with ½-inch maximum spaces between wood planks.
 - 4. Overall Width: 87.5-inches
 - 5. Overall Depth: 23.5-inches
 - 6. Arms: None.
 - 7. Back: None.
 - 8. Seating Configuration: Multiple units as indicated.
 - a. Straight shape.
 - b. Designed to support 200 lbs. per lineal foot.
 - 9. Color: As indicated by manufacturer's designation.
- D. Steel Finish: Galvanized and powder coated.
 - 1. Steel Gauge: 7-gauge powder coated steel frame and mounts.
 - 2. Color: “Grey” As indicated by manufacturer's designation and as selected by Architect from manufacturer's full range.
- E. Wood Finish: Manufacturer's standard finish with manufacturer Cutek Extreme Wood Protection Oil.
- F. Warranty: 20-year structural, 10-year Ipe wood, 3-year finish warranty from Substantial Completion.

2.2 SURFACE-MOUNT BENCH

- A. Basis of Design: Provide Landscape Forms “Extasi” cast stone bench or approved equal.
- B. Seat:
 - 1. Material:

- a. Cast stone.
 - 2. Seat Height: 18-inches
 - 3. Overall Width: 65- inches
 - 4. Overall Depth: 65- inches
 - 5. Seating Configuration: Multiple units as indicated on plans.
 - a. Triangular shape.
 - 6. Color: "White".
- C. Warranty: 20-year structural, 3-year finish warranty from Substantial Completion.

2.3 MATERIALS

- A. Steel and Iron: Free of surface blemishes and complying with the following:
- 1. Plates, Shapes, and Bars: ASTM A36/A36M.
 - 2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
 - 3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
 - 4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
 - 5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
- B. Stainless Steel: Free of surface blemishes and complying with the following:
- 1. Pipe: Schedule 40 steel pipe complying with ASTM A312/A312M.
 - 2. Tubing: ASTM A554.
- C. Anchors, Fasteners, Fittings, and Hardware: Stainless steel or Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
- D. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.
- E. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.
- F. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:

1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.
2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.4 WOOD-PRESERVATIVE-TREATED MATERIALS

- A. Preservative Treatment: Thermory treated wood.
 1. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

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; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all 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 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.

2.8 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. Dull Satin Finish: ASTM A480/A480M, No. 6.

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. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

END OF SECTION 323300

SECTION 329300 - PLANTING

1.01 SYSTEM DESCRIPTION

- A. System includes providing planting work complete in place, including but not limited to:
 - 1. Clearing and grubbing.
 - 2. Pre-planting weed control.
 - 3. Imported planting soil.
 - 4. Soil preparation and conditioning.
 - 5. Finished grading of landscape areas.
 - 6. Plant materials and planting, including watering, spraying, and fertilizing.

1.02 SUBMITTALS

- A. Submit duplicate samples and certificates for the following items and any other materials as may be required by the Architect.
 - 1. Soil Amendments: Samples and manufacturer's certificate.
 - 2. Fertilizers: Samples and manufacturer's certificate. Include ½ pound each of controlled-release fertilizer and four tablets each of 5 gram and 21 gram controlled-release fertilizer tablets.
 - 3. Soils laboratory report for imported planting soil.
- B. Obtain written acceptance before beginning fabrication or delivery of material to the site. Finished work shall match approved samples.
- C. Furnish certificates with each delivery of material to the site, both in containers and in bulk, stating source, quantity or weight, type and analysis, and date of delivery. Deliver certificates to the Architect.
- D. Construction Schedule: At the pre-construction meeting, provide a written projected planting schedule noting the estimated completion date, number of working days required, and any special coordination requirements.

1.03 SAMPLES AND TESTING

- A. Architect reserves the right to take and evaluate samples of materials for conformity to Specifications at any time. Furnish samples upon request by the Architect. Immediately remove rejected materials from the site.

1.04 VERIFICATION OF DIMENSIONS AND QUANTITIES

- A. Scaled dimensions are approximate. Before proceeding with any work, carefully check and verify dimensions and quantities, and immediately inform the Architect if any discrepancy occurs between the Drawings and Specifications and actual conditions. Perform no work in any area where there is such a discrepancy until acceptance has been given by the Architect.

- B. Furnish and install work indicated on the Drawings by notes, whether or not specifically mentioned in the Specifications. Any items not specifically indicated or specified, but normally required to conform with such intent, are considered part of the work. The Architect reserves the right to make field adjustments and reasonable substitutions to insure implementation of the landscape concept in relation to field conditions.

1.05 MATERIALS DELIVERY AND STORAGE

- A. Deliver manufactured materials in original containers with brand and maker's name marked thereon. Materials in broken containers or showing evidence of damage will be rejected and must be immediately removed from the site. Do not bring odorous materials to the site until they are to be used.
- B. Protect plants in transit and after delivery to the site. Plants in broken containers and plants with broken branches or injured trunks will be rejected. Remove rejected material from the site immediately.

1.06 JOB CONDITIONS

- A. Acceptance of Previous Work: Inspect and accept the condition of the site relative to this Section before commencing with this work. If not acceptable, notify the Architect in writing. By proceeding with the work, the Contractor indicated his acceptance of all previous related work.
- B. Meet on Site: Prior to commencing work, meet with the Architect and other concerned parties on site to review the work. Request this meeting one week prior to desired meeting time.
- D. Underground Utilities and Obstructions: Verify the location of underground utilities and other obstructions that may affect the work. Report obstructions encountered to the Architect. Repair all damages to any known utility line or other underground obstruction. Report damage to any unknown utilities to the Architect.
- D Protection:
 - 1. Provide necessary safeguards and exercise caution against injury or defacement of existing site improvements. Prevent vehicles of any kind from passing over sidewalks, curbs, and similar items, unless adequate protection is provided. Do not store materials or equipment, or operate equipment near or under the branches of any existing plants that are to remain, except as actually required for construction in those areas.
 - 2. Be responsible for any damage resulting from landscape planting operations. Repair all damage to return the area to the previous condition.
 - 3. Protect areas susceptible to traffic by erecting barricades immediately after planting.

- E. Clean Up: Keep areas of work clean, neat, and orderly at all times. Clean construction areas at the end of each day, including during planting and maintenance operations.

1.07 WARRANTY

- A. Plant Material
1. Warrant in writing all plant materials relocated for a period of one year from the date of final acceptance against improper installation, and defective, unsound, or diseased conditions that may appear.
 2. Upon receipt of written notice from the Architect of the death of any warranted plant materials during the warranty period, promptly replace within 5 days the subject plant materials with same species as originally planted, and of a size closely approximating the size of the plant if normal growth had occurred since the original planting. Replacement is subject to all requirements of the Specifications.
 3. When plants are replaced, advise the Owner, in writing, of the necessary establishment maintenance which must be performed.
 4. The expense of replacement shall be borne by the Contractor.
- B. Liability: The liability under the warranty includes the repair of damage to the work of other contractors, or damage to the Owner's property caused by the failure of this work. All of the provisions of this Section apply to work performed to satisfy the requirements of the warranty.

1.08 PLANT MATERIALS:

- A. Nomenclatures: Plant names listed on Drawings conform to Standardized Plant Names established by American Joint Committee on Horticultural Nomenclature; except that for names not covered therein, the established custom of the nursery trade is followed.
- B. Quantities: Furnish plant materials in quantities required to complete the work as indicated on the Drawings.
- C. Condition:
1. Furnish plant materials with a normal habit of growth, and sound, healthy, vigorous and free from insect infestation.
 2. Minimum measurements for field stock trees indicated on the Landscape Material List are measurements taken after pruning.
 3. Stolons: Healthy, vegetative material with well-established roots at one or more nodes.
- D. Groundcover shall be provided for weed control. Type and layout shall be as per design plans

1.09 IMPORTED SCREENED SOIL:

- A. Shall be screened, (1/2" screen), natural fertile, friable soil free of stones, noxious seeds, roots, sticks, weeds, (especially nutgrass), subsoil in any quantity. Soil should have satisfactory loam characteristics, and it shall not be screened subsoil.
 - B. Imported soil shall contain sufficient quantities of available nitrogen, phosphorus, potassium, calcium and magnesium to support normal plant growth or be amendable to support normal plant growth in accordance to the soil analysis recommendations.
- 1.11 FERTILIZERS AND SOIL CONDITIONERS: First-quality, standard-brand, agricultural products. Do not use fertilizer that would stain adjacent concrete surfaces.
- A. Chemical Fertilizer: Controlled-Release Fertilizer: 16-7-12 (N-P-K) with controlled-release fertilizer tablets of 5 and 21 grams, 10-10-5 (N-P-K).
 - B. Organic Soil Conditioner: "Eko-Compost", or other acceptable equal organic material.
 - C. Hydromulch: Specially processed fiber containing no growth inhibiting factors.
- 1.12 BACKFILL MIX: 4 parts of Imported Planting Soil and 1 part of approved Organic Soil Conditioner.
- 1.13 PRE-PLANTING HERBICIDE: Round-Up or equal.
- 1.14 PRE-EMERGENT WEED CONTROL: Pre-emergent herbicide (Treflan R , Dymid R, Ronstar-G, Eptam, Vegitex or Enide R) or acceptable equal. Verify compatibility with proposed plant list. Bring any questionable plants to the attention of the Architect for a decision prior to application. Apply in strict conformance with the manufacturer's recommendations, including application methods and rates.
- 1.15 WATER: Unless noted otherwise, potable water will be readily available at no additional expense.
- 1.16 MISCELLANEOUS MATERIALS:
- A. Tree Guys:
 - 1. Anchors: 1-inch galvanized pipe, 3 feet long.
 - 2. Wires: 1-1/8 inch flexible galvanized cable.
 - 3. Hose Collars: Fabric-reinforced rubber hose, flat black color.
 - 4. Tubing: Polyethylene, grey, 1/2 inch diameter, when guying occurs in lawn areas.
 - 5. Cable Clamps: Galvanized.
 - 6. Turnbuckles: 6-inch, open turnbuckle, eye and fittings, 5/16-inch in diameter. Four 1-1/4-inch take up, all galvanized, weldless, drop-forged steel.
 - 7. Tree Trunk Protector: Polyethylene, grey, individual wraps or in spiral coil.
 - B. Tree Stakes:

1. Stakes: 2 inches by 2 inches by 8 feet rough construction grade redwood or douglas fir with chamfered top and pointed bottom, or approved equal.
 2. Ties: Fabric-reinforced, corded, rubber straps as manufactured by "Gro-Strait", Walnut Creek, CA, 3/8-inch x 3/4 inch length required by tree-staking details indicated on the Drawings. Fasten to stake as noted on Drawings.
- C. Marker: Plastic surveyor tape. Bright color, minimum 2 feet long. Use same color throughout project.
- D. Other Material:
1. Root Barriers: 19.5" deep Typar 'Biobarrier' or approved equal.
 2. Gravel: 4" depth, #3 B Fine.

1.17 CLEARING:

- A. Clean weeds and debris from ground areas to be planted prior to any soil preparation or grading work. Remove noxious weeds and grasses by the roots wherever they are found at any stage of the work. Dispose of weeds and debris off the site.
- B. Remove from the site soil contaminated by cement, paint, plaster, herbicides, or other construction debris and replace with same quantity of soil. Obtain acceptance of replacement soil from the Architect prior to placement.

1.18 PRE-PLANTING WEED CONTROL: Apply pre-planting herbicides to visible weeds, before and after soil placement.

1.19 PROTECTION:

- A. Protect planted areas and plants against trespassing and damage at all times. If any plants are damaged, treat or replace as directed by the Architect.
- B. Do not execute work in or over prepared plant areas or adjacent to planting without proper safeguards and protection.

1.20 SOIL PREPARATION:

- A. Subgrades will be established under EARTHWORK Section. Do not start soil preparation until rough grades have been accepted by the Architect. Allow for depth of soil amendments in determining the difference between finished subgrade in ground cover and shrub beds. Verify that subgrades are not compacted. Do not proceed until condition is corrected.
- B. Maintain previously established grades and swales.

- C. Moisture Content: Do not work the soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in air or that clods will not break readily. Apply water, if necessary, to bring soil to an ideal moisture content for tilling and planting.
- D. Uniformly distribute a 1 inch layer of organic soil conditioner and the fertilizer specified by the soil analysis over all shrub and ground cover areas.
- E. Roto-till the top 4 inches of all planting areas, to evenly incorporate the amendments into the soil.

1.21 FINE GRADING:

- A. Adjust finish grading with imported screened soil as necessary. Provide grades smooth and even on a uniform plane with no abrupt changes or pockets, and slope away from all buildings. Verify the surface drainage of all planting areas, and notify the Architect of any discrepancies, obstructions, or other conditions considered detrimental to proper execution of the work.
- B. Tie landscape work to existing conditions and controls, such as existing trees and landscape features, utility lines, pavement, and curbs. Finished grades will bear proper relationship to such controls. Adjust new work as necessary to meet the conditions and fulfill the intention of the Drawings.
- C. After initial settlement, the finish grade will be lower than adjacent walks, curbs, and headers:
 - 1. Bermuda and Other Fine Grasses: ½ inch - ¾ inch.
 - 2. Shrubs and Ground Covers: 1 inch - 1-1/2 inches.
- D. Immediately prior to planting operations, clean weeds from planting areas and remove debris, rocks over 1 inch in diameter, and clumps of earth that will not break up.

1.22 SOIL AND DRAINAGE CONDITIONS:

- A. Notify Architect in writing of soil or drainage conditions encountered during planting operations which the Contractor considers detrimental to growth of plant material. Include a cost proposal for the correction of the problem. Obtain approval before proceeding with work.
- B. If drainage conditions of plant pits appear unsatisfactory, test drainage by filling with water. Bring to the attention of the Architect conditions permitting the retention of water in planting pit for an excessive period of time.

1.23 HANDLING PLANTS:

- A. Handle plants in a manner to avoid any damage to the plant.

- B. Protect plants at all times from sun or drying winds. If plants cannot be planted immediately upon delivery, keep in the shade, protect, and water adequately.
- C. Plant relocated trees within 24 hours after they are removed from their original site.

1.24 PLANTING PITS:

- A. Planting Pits:
 - 1. Locate planting pits per Planting Plans, bringing any conflict with underground utility lines to the attention of the Architect. Stake locations for holes on the site, and obtain the Architect's acceptance prior to excavating.
 - 2. Excavate round holes twice the diameter and 1-1/2 times the depth of the root ball/container, or to the sizes and depths indicated on the Drawings.
 - 3. Scarify the sides and bottom of the holes.
- B. Backfilling:
 - 1. Backfill the planting holes with the special backfill mix herein specified.
 - 2. Water-settle backfill thoroughly or compact by other acceptable method prior to planting, so plants do not settle.
- C. Fertilizer Tablets: Prior to filling each planting hole with backfill mix, place tablets in holes per manufacturer's written recommendations.

1.25 PLANTING OPERATION:

- A. General:
 - 1. Do not install plant materials until construction work has been completed, and landscape sprinkler systems have been installed and tested; planting areas have been graded, prepared, and accepted by the Architect.
 - 2. Do not plant during unfavorable weather.
 - 3. Make sure soil is at an optimum moisture content for planting. Do not plant in dry or muddy soil.
- B. Container and Larger Plants:
 - 1. Do not lift or handle container plants by tops, stems, or trunks at any time.
 - 2. Set plants so that, when settled, the natural grade in the container is 2 inches above finished grade of other planting beds.
 - 3. Watering Basins: Form circular earth basin centered on the stem of each plant with the rim of the basin 3 inches above the grade at the stem. Do not form watering basins around trees in lawn areas. Continue ground cover planting through watering basins.
 - 4. Install plants immediately after the containers are cut, and remove containers from the site so as not to present a hazard to persons using the area.

- 5. Upon completion of planting operations and again just prior to final inspection, lightly cultivate and neatly rake soil between plants. Leave basins around plants unless otherwise specified or directed by the Architect.
 - 6. Staking and Guying: Immediately after planting, stake and/or guy all trees and palms as necessary. Install tree trunk protector.
- C. Pre-emergent Weed Control: Immediately after planting, apply pre-emergent weed control material to planted areas which will not be seeded.
- 1.26 TREE STAKING: Double-stake 15- and 25-gallon trees, except multi-trunk trees. Single stake 5-gallon trees.
- A. Set stakes at right angles to the prevailing wind.
 - B. Set stakes plumb.
 - C. Securely nail rubber straps to stakes using ring shank nails.
 - D. Set up a sample stake and ties, and obtain Architect's acceptance prior to installing tree stakes and ties.
- 1.27 TREE GUYING: Guy field stock and all boxed trees
- A. Neatly form hose and cable collars to prevent any bare cable from chafing against the tree trunk or branches.
 - B. Do not leave sharp cable ends protruding.
 - C. Install grey polyethylene marker tubing on guy wires when planting in lawn areas.
- 1.28 PRUNING AND SPRAYING:
- A. Prune plants only at time of planting and according to standard horticultural practice to preserve the natural character of the plant and to accomplish its use in the landscape design.
 - B. Remove dead wood, suckers, and broken or badly bruised branches.
 - C. Remove only dead, broken, or rubbing branches on flowering specimen trees and shrubs. Remove other branches only as directed by Architects.
 - D. Use only clean, sharp tools.
 - E. Immediately after planting operations are complete, dress off beds and pits to achieve a neat appearance.

- 1.29 CLEANUP: Remove cans, surplus materials, and other debris from site. Neatly dress and finish planting areas. Flush walks, paved areas, and similar surfaces clean to the satisfaction of the Architect.
- 1.30 PLANTING MAINTENANCE:
- A. Maintain all plants and planted areas in optimum growing condition and appearance.
 - B. Begin maintenance with the delivery of the first plant materials to the site, and continue until the acceptance of the final inspection.
 - C. Maintenance includes, but is not limited to:
 - 1. Protect areas susceptible to traffic by erecting barricades immediately after planting.
 - 2. Irrigate planting areas as required to insure active growth, keeping areas moist but not saturated. Regulate irrigation as necessary to avoid erosion and gulying.
 - 3. Fertilize as needed in accordance with the manufacturer's recommendation and five days prior to final inspection. Exercise proper caution and take measures necessary to avoid plant burn.
 - 4. Keep planting areas free of weeds and undesirable grasses through daily weeding if required. Keep planting areas, including lawns, neat and free from debris at all times and cultivate and weed at not more than 10-days intervals. Remove the entire root system. Dispose of weeds in appropriate trash containers.
 - 5. Inspect all plants, including lawn, for disease or insect damage weekly. Treat affected material immediately.
 - 6. Remove damaged or diseased growth from trees and shrubs.
 - 7. Immediately remove dead or dying plants not in a vigorous thriving condition. Replace with the same species and size as originally planted.
 - 8. Restake, tighten, repair guys, and reset to proper grades or upright position any plants that are not in their proper growing position.
 - 9. Mow lawn to a 1 inch height whenever the average height exceeds 1-1/2 inches. Remove clippings.
 - 10. As it becomes evident that certain lawns and ground covers are not uniformly or properly established, replant the areas immediately with the same plants and quantity as specified for the initial planting. Maintain as specified for 90 percent coverage of healthy, actively growing grass and ground covers for acceptance during the final inspection.
- 1.31 FINAL INSPECTION:
- A. At the completion of all landscape installation, hold the Final Inspection.
 - B. Request the inspection of the Architect 5 working days prior to the completion of work, in order that a mutually agreeable time for inspection may be arranged.

- C. The Architect, Contractor, and Owner, or their representatives, shall be present at the inspection.
- D. At the time of inspection, have areas free of weeds, dead leaves, and trash, neatly cultivated and raked. Have all stakes, guys, and plant basins in good order. At the Final Inspection, neatly cut lawns and remove all clippings.
- E. If, after the Final Inspection, the Architect and the Owner are of the opinion that the work has been performed in accordance with the Drawings and Specifications, written notice of acceptance and completion of the Project will be given.
- F. If portions of the work are not acceptable, a reasonable amount will be retained from the final payment until the defects have been corrected and the work is accepted by the Architect and the Owner.

END OF SECTION

SECTION 330526 - PIPE IDENTIFICATION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Work included in this section shall pertain to the identification of potable water, industrial water, chilled water supply/return and gas buried piping in the site. The work shall include but not be limited to the installation of identification/warning tape, copper tracing wire, and color coding on pipe.

PART 2 - PRODUCTS

2.1 IDENTIFICATION/WARNING TAPE

- A. All utility piping shall be installed with 3 inch wide metallic or vinyl continuous tape, for identification and warning purposes, buried directly above the centerline of the pipe at a maximum depth of 18 inches or as approved by the Work's engineer of record.
- B. The identification/warning tape shall be colored and labeled as follows:
1. Potable Water Main Tape.
 - a. Color: Blue with Black Lettering
 - b. Lettering: "CAUTION: WATER LINE BURIED BELOW" or similar wording.
 2. Reuse Water Main Tape.
 - a. Color: Purple with Black Lettering
 - b. Lettering: "CAUTION: REUSE WATER LINE BURIED BELOW" or similar wording.
 3. Brine Water Main Tape.
 - a. Color: Orange with Black Lettering
 - b. Lettering: "CAUTION: BRINE WATER LINE BURIED BELOW" or similar wording.
 4. Gas Main Tape.
 - a. Color: Yellow with Black Lettering
 - b. Lettering: "CAUTION: GAS MAIN BURIED BELOW" or similar wording.
 5. Raw Water Main Tape.
 - a. Color: Green with Black Lettering
 - b. Lettering: "CAUTION: RAW WATER MAIN BURIED BELOW" or similar wording.
 6. Sewer Main Tape.
 - a. Color: Brown with White Lettering
 - b. Lettering: "CAUTION: SEWER MAIN BURIED BELOW" or similar

wording.

- 7. Force Main Tape.
 - a Color: Brown with White Lettering
 - b Lettering: “CAUTION: FORCE MAIN BURIED BELOW” or similar wording.

C. All lettering shall appear legibly on the tape and shall run the entire length of the pipe.

2.2 COPPER IDENTIFICATION WIRE

- A. All non-metallic pipe shall be installed with a continuous, insulated 14 gauge copper wire installed directly on top of the centerline of the pipe for location piping.

2.3 PIPE COLOR IDENTIFICATION

- A. All potable water, industrial water, chilled water and gas main utility piping shall be marked with a continuous minimum 2” paint stripe located at the 12’o clock position or the pipe shall be a solid color as follows:

1. Potable Water Line Stripe or Pipe Color:	Blue
2. Reuse Line Stripe or Pipe Color:	Purple
3. Brine Water Line Stripe or Pipe Color:	Orange
4. Gas Main Stripe or Pipe Color:	Yellow
5. Raw Water Main Stripe or Pipe Color:	Green
6. Force Main Stripe or Pipe Color:	Brown
7. Sewer Water Main Stripe or Pipe Color:	Brown

- B. Backfill shall not be placed for 30 minutes following paint application.

PART 3 - EXECUTION

3.1 PIPE WRAPPING

- A. All reinforced concrete pipes and corrugated high density polyethylene pipes must be wrapped securely to ensure the joints are not exposed to the elements.
- B. There must be no dirt allowed in the system or the wrapping.

END OF SECTION 330526

SECTION 331110 - POTABLE AND REUSE WATER DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section shall include, but not be limited to, all labor, equipment, tools, materials and all incidentals required for the construction, installation, testing and disinfection of a potable and reuse water distribution systems, including all appurtenances as shown on the Drawings and as specified herein. All references to and requirements for “potable water” or “water” systems contained in this section shall also apply to the industrial water system.
- B. The work shall include but not be limited to, ductile iron pipe, PVC pipe, high density polyethylene (HDPE) pipe, valves, air release and vacuum valves, pressure reducing or sustaining valves, ductile iron fittings, strainers, tapping tees and sleeves, tapping saddles, cast iron valve boxes, backflow preventers, master meters, valve vaults and boxes, all restrained joints as required for all types of piping, all excavation, sheeting, shoring and bracing, dewatering, jacking and boring, where required, slope protection, backfilling, grading and drainage, concrete work, rip-rap, compaction, grass restoration, pavement restoration, where required, and all other work necessary to complete the construction, installation, testing and disinfection of the potable water distribution system.

1.2 RELATED SECTIONS

- A. Soils Report and Other Information
- B. Shop Drawings, Product Data and Samples
- C. Site Preparation
- D. Excavating and Backfilling for Utilities

1.3 QUALITY ASSURANCE

A. Reference Standards:

DIPRA Handbook of Ductile Iron Pipe.
Uni-Bell Handbook of PVC Pipe.
Recommended Standards for Water Works, (Ten-State Standards)
Florida Department of Environmental Protection, F.A.C. 62-500.
Canadian International Standard (ISO)

B. Reference Specifications:

- 1. This standard references the following documents, which forms a part of this standard to the extent specified herein. In any case of conflict, the most restrictive standard shall prevail. For all reference specifications, the latest edition shall apply.
 - a. ASTM D746 (ANSI/AWWA C151/21.51) Ductile Iron Pipe.
 - b. ASTM A536 (ANSI/AWWA C153/A21.53) Compact Ductile Iron Fittings.
 - c. (ANSI/AWWA C110/A21.10) Ductile Iron Fittings, 3 inches through 48 inches, for Water and Other Liquids.

- d. (ANSI/AWWA C104/A21.4) Cement Mortar Lining For Ductile Iron Pipe and Fittings For Water.
- e. (ANSI/AWWA C111/A21.11) Rubber Gasket Joints For Ductile Iron Pipe and Fittings.
- f. AWWA C600, Installation of Ductile Iron Water Mains and Appurtenances.
- g. ANSI/AWWA C105/A21.5, Polyethylene Encasement For Ductile Iron Piping For Water and Other Liquids.
- h. ASTM D1784, Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.
- i. ASTM D2241 (AWWA C900), Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe.
- j. ASTM F477, Elastomeric Seals for Joining Plastic Pipes.
- k. ASTM D3139, Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
- l. ANSI/AWWA C500, Standard For Gate Valves For Water and Sewage Systems.
- m. ANSI/AWWA C509, Standard For Resilient Seated Gate Valves For Water and Sewage Systems.
- n. ANSI/AWWA C504, Standard For Rubber-Seated Butterfly Valves.
- o. AWWA C503, Standard For Wet Barrel Fire Hydrants.
- p. AWWA C906-90, Polyethylene Pipe and Fittings for Water Distribution
- q. ASTM C478, Precast Concrete Valve Boxes and Vaults.
- r. ASTM C94, Concrete, Type II.

C. INSPECTION AND CERTIFICATION OF PIPE AND FITTINGS:

- 1. All pipe fittings and appurtenances to be installed under this Section may be inspected and tested for compliance with these Specifications at the manufacturer's facility by an independent testing laboratory selected by the Contractor. The manufacturers' cooperation shall be required in these inspections.
- 2. The Contractor shall obtain from the pipe manufacturer a certificate of inspection stating that the pipe and fittings supplied for this Work has been inspected and tested at the point of origin, and that they meet or exceed the requirements set forth in these Specifications.
- 3. The costs of the inspections and tests shall be borne by the Contractor. Letters of certification shall be furnished for all inspections and tests prior to the installation of the pipe, fittings and appurtenances.

E. INSPECTION UPON DELIVERY:

- 1. All pipe fittings and appurtenances shall be subject to visual inspection at the point of delivery and again just before being lowered into the trench. All materials found to be defective due to manufacture, or damaged in transit shall be rejected and shall be immediately removed by the Contractor from the job site.
- 2. The Owner or the Utility may perform or cause to be performed all tests as specified in the applicable AWWA Standards, to ensure conformance with the standard. In the case of failure of the pipe or appurtenances to comply with such standards, the responsibility for replacement of the defective materials becomes that of the Contractor.
- 3. The entire product of any manufacturer may be rejected when, in the opinion of the Design Engineer or the Utility Owner, the methods of manufacture fail to secure uniform results, or where the materials are such as to produce pipe and/or fittings of inferior quality.

1.4 EXPERIENCE

- A. The Contractor shall be a firm with not less than five (5) years of successful experience in the installation and construction of pipelines incorporating products and materials similar to those specified herein.

1.5 HANDLING AND STORAGE OF PIPE FITTINGS AND APPURTENANCES

- A. All pipe, fittings and appurtenances shall be loaded and unloaded by lifting with hoists or skidding in order to avoid shock or damage.
1. Pipe, fittings and appurtenances shall not be dropped, rolled or skidded into or against pipe, fittings or other construction products on the ground.
 2. Slings, hooks, pipe tongs and other lifting devices shall be padded and used in such a manner as to prevent damage to pipe or construction products.
 3. Stored materials shall be kept safe from damage. The interior of all pipe, fittings and appurtenances shall be kept free from dirt, oil, grease and foreign matter at all times.
- B. Pipe shall not be stacked higher than recommended by the manufacturer or the limits shown in the following table, whichever is most stringent.

MAXIMUM STACKING HEIGHTS FOR PIPE

NOMINAL PIPE SIZE (INCHES)	4	6	8	10	12	14	16	18
20 24 30	36	42						
NUMBER OF TIERS	16	13	11	10	9	8	7	6
6 5 4	4	3						

The bottom tier shall be kept off of the ground on timbers. Pipe in tiers shall be alternated, i.e., bell, plain end; bell, plain end, etc. No less than two rows of timbers shall be placed between tiers. Chocks shall be affixed to each, in order to prevent movement. The timbers shall be large enough to prevent contact between pipe in adjacent tiers.

- C. The Contractor shall cover stored PVC and polyethylene pipe to prevent exposure to ultraviolet radiation.
- D. Pipe gaskets shall be used in the work on a first-in, first-out basis.
1. Gaskets for mechanical joint and push-on joint ductile iron pipe and fittings shall be stored in a cool, dry location, out of direct sunlight.
 2. Gaskets shall be stored in such a manner so as to prevent coming into contact with petroleum products.
- E. Mechanical joint bolts and locking segments for push-on joints shall be handled and stored in such a manner that will ensure proper use with respect to pipe types and sizes.

1.6 TESTING AND INSPECTION

A. Refer to Division I.

B. TEST METHODS AND INSPECTIONS:

1. Maximum density and optimum moisture content of soils in place and field density of soils in place shall conform to Section Excavation and Backfill for Utilities.
1. Hydrostatic pressure and leakage testing of potable water mains in accordance with AWWA C600, latest edition, and in accordance with Part 3.09 of this Section.
2. Disinfection and testing of potable water pipelines in accordance with AWWA C651, latest edition, AWWA Manual M12, and Part 3.10 of this Section.

1.7 REQUIREMENTS

- A. Unless indicated otherwise in the Drawings or as specified herein, the minimum cover for potable water mains shall not be less than 36 inches.
- B. Potable water mains shall be laid in the dry. All work occurring at trench depths below groundwater level shall be dewatered and maintained in a dry condition continuously while work is taking place at those elevations. All dewatering shall conform to the requirements of Section Dewatering.
- C. Where Ductile Iron Pipe are to be laid in or at the surface of brackish ground water the pipes shall be protected with polyethylene encasement in accordance with AWWA C105, from the adverse external aggressive soil and or ground water conditions.
- D. Potable water mains and appurtenances shall be constructed using the materials indicated on the Drawings and as specified herein, substitutions shall not be made without the expressed approval of the Engineer or Owner and the Utility.
- E. The Contractor shall not cover lines until they have been inspected and approved, and all required testing has been performed and passed.
- F. Conflict encasement shall be in accordance with the Drawings.
- G. Air relief manholes and air and vacuum relief valves shall be installed as indicated on the Drawings. Air relief manholes and valves shall be in accordance with 2.01 G. of this Section.

1.8 SUBMITTALS

A. PROCEDURES:

1. Submit product data, shop drawings, samples, testing laboratory reports, etc. in a timely manner and in accordance with the general requirements of Division I: Shop Drawings, Product Data and Samples.

B. PRODUCT DATA:

1. Submit manufacturer's detailed product literature, which shall include, where applicable, mill test reports, equipment capacity data, manufacturer's literature that notes compliance

with the reference standards including, but not limited to, product type, pressure rating, schedule, class, grade, and all other information pertinent to the installation.

2. The data to be submitted shall include, but not be limited to:
 - a. Ductile iron pipe and fittings.
 - b. Polyvinyl chloride (PVC) pressure pipe.
 - c. Elastomeric seals for ductile iron and PVC pipe joints.
 - d. Polyethylene pipe and fittings.
 - e. Resilient seated gate valves.
 - f. Air and vacuum relief valves.
 - g. Tapping tees and tapping sleeves.
 - h. Cast iron valve boxes.
 - i. Precast concrete valve vaults.
 - j. Valve operators.
 - k. Mechanical joint retainer glands. (UL/FM)
 - l. Corrosion protection materials.
 - m. Underground marker tape.
 - n. Underground tracer wire and appurtenances.
 - o. Fire hydrants and fittings.
 - p. Pressure reducing or sustaining valves.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. Ductile iron pipe (DIP) and fittings for potable water service shall conform to ANSI/AWWA C151/A21.51.
 1. Ductile iron pipe shall have a minimum tensile strength of 60,000 p.s.i. with a minimum yield strength of 42,000 p.s.i.
 2. Pipe thickness shall be in accordance with Table 50.12, ANSI/AWWA C150/A21.50 and shall be Pressure Class 350.
 3. Ductile iron pipe for potable water main service shall have a cement mortar lining and a bituminous seal coat in accordance with ANSI/AWWA C104/A21.4 and a minimum 1.0 mil bituminous coating on the pipe exterior in accordance with ANSI 21.51.
 4. Unless specifically required by the Drawings, Ductile iron pipe shall be supplied in lengths not in excess of a nominal 20 feet, and unless otherwise specified, shall have mechanical joints conforming to Table 10.1 ANSI/AWWA C110/A21.10. Single gasket push-on joints on mechanical joints conforming to ANSI/AWWA A21.11/C111 shall be used on all ductile iron pipe except where restrained joints are required.
 5. High strength, low alloy mechanical joint T-bolts and nuts conforming to ANSI/AWWA C111/A21.11.
 6. Mechanical joint gaskets shall conform to ANSI/AWWA C111/A21.11, latest revision.
 7. Where called for on the Drawings, polyethylene encasement for ductile iron pipe shall conform to ANSI/AWWA C105/A21.5.
 8. Acceptable manufacturers:
 - a. U.S. Pipe.
 - b. American.

- c. Clow.

B. COMPACT DUCTILE IRON FITTINGS:

1. Potable water distribution pipe fittings shall be ductile iron conforming to ANSI/AWWA C153/A21.53.
 - a. Rubber gasket joints shall conform to ANSI/AWWA C111/A21.11.

C. FLANGED DUCTILE IRON PIPE AND FITTINGS WITH THREADED FLANGES:

1. Flanged ductile iron pipe and fittings, where called for on the plans, shall conform to ANSI/AWWA C115/A21.15.
2. Flanges shall be furnished flat faced and drilled to 125-pound template in accordance with B16.1 full-faced gaskets.
3. Acceptable manufacturers:
 - a. U.S. Pipe.
 - b. American.
 - c. Clow.

D. Polyvinyl chloride (PVC) pressure pipe and fittings for potable water service, in sizes 4-inch through 12-inch shall conform to AWWA C900, latest revision.

1. Laying lengths shall be 20 feet $\pm$ 1 inch for all sizes.
2. PVC pipe shall be Class 150 (SDR 18) with cast iron outside dimensions.
3. PVC pipe joints shall have an integral wall-thickened bell end with gasket seal conforming to ASTM D3139. Solvent weld joints will not be permitted.
4. All PVC pipe shall be identified on the exterior of the pipe with the following information:
 - a. Nominal pipe size and O.D. base.
 - b. Material code designation number.
 - c. Dimension ratio number.
 - d. AWWA pressure class.
 - e. AWWA designation.
 - f. Pipe manufacturers name and production code.
 - g. All PVC pipe shall be UL-FM approved.
5. PVC pipe smaller than 4-inch in size shall be 200 psi, (SDR-14) in I.P.S. dimensions, manufactured from 1120 resin.
6. Acceptable manufacturers:
 - a. Johns Manville.
 - b. Certainteed.
 - c. H&W.
 - d. Clow.

E. Polyethylene pipe pressure pipe and fittings for potable water service, in sizes 4-inch through 63-inch shall conform to AWWA C906, latest revision.

1. Polyethylene pipe shall have a minimum pressure rating of 150 psi.
 2. Size of pipes as shown on the plans refer to minimum inside diameter of pipes. Exceptions may be made on a case by case basis.
- F. Resilient seated wedge gate valves for potable water service shall conform or exceed all applicable requirements of AWWA C509.
1. All resilient seated wedge gate valves shall have non-rising stems fitted with O-Ring seals for counter clockwise operation and a 2-inch square operating nut.
 2. All resilient seated wedge gate valves shall be bubble tight at 200 psi.
 3. Each valve shall have the manufacturer's name, pressure rating, the year of manufacture, and an arrow to indicate the direction of opening cast into the valve body.
 4. The interior of the valve body and bonnet shall have a factory applied 2-part thermo setting epoxy resin lining equal to Endurall 3300.
 5. Each valve shall be hydrostatically tested to a pressure equal to twice the specified working pressure prior to shipment from the factory. The manufacturer shall certify each valve.
 6. Acceptable manufacturers:
 - a. American Flow Control (Series 2500)
 - b. Or Approved Equal
- G. AIR RELEASE VALVES for potable water service shall be installed as shown on the Drawings. The valves shall be constructed with a cast iron body, cover and baffle, stainless steel float, bronze water diffuser, BUNA-N or viton seat and stainless steel trim.
1. Valves shall be provided with a vacuum check to prevent air from re-entering the line. All fittings shall be threaded.
 2. Air release valves shall be Model 200 as manufactured by Apco Valve and Primer Corporation, Schaumburg, Illinois.
- H. CORPORATION STOPS: The use of direct tapping into pipe using corporation stops for water service connections will not be approved.
1. All service taps shall be made using approved type service saddles.
 2. Service saddles shall not be less than 2 inches.
- I. SERVICE SADDLES OR TAPPING SLEEVES
1. Size-on-size taps using tapping saddles or sleeves will not be permitted.
 2. Where size-on-size outlets are required, a tee shall be installed in lieu of a tapping saddle or sleeve. Tapping saddles and tapping sleeves will only be permitted on lines that are at least one nominal pipe size or diameter larger than the proposed tap.
 3. Tapping saddles and tapping sleeves shall be ductile iron and shall be epoxy, nylon or PE coated (min. 10 mils).
 4. Approved manufacturers:
 - a. Rockwell.
 - b. Mueller.
 - c. Ford.
 - d. Romac.

- e. Cascade.
- 5. Tapping sleeves for use on pipe 14 inches and larger in diameter shall be ductile iron with mechanical joint.
- 6. Acceptable manufacturers:
 - a. Clow.
 - b. Mueller.
 - c. American.
 - d. Dresser.
- 7. Tapping sleeves for use on water mains 12-inches in diameter and smaller shall be fabricated of 18-8 stainless steel for corrosion resistance. The outlet of the tapping sleeve may be either extruded or welded to the tapping sleeve. All welds shall be fully passivated to restore the stainless steel quality and characteristics. The flange shall be stainless steel with a recess to accept standard tapping valves. The flange shall conform to AWWA C-207, Class D, ANSI 150 lb. drilling. Bolt holes shall straddle the pipe centerline.
- 8. The sleeve shall be equipped with a 3/4 inch NPT 18-8 stainless steel plug with a standard square head for testing. The gasket shall be of 360-degree design, and manufactured of gridded virgin GPR (Ground Penetrating (Probing) Radar) compounded for water service and complying with ASTM D-2000-80M 4AA607. An 18-10 stainless steel armor shall be vulcanized to the gasket, to bridge the gap between the securing lugs.
- 9. All bolts and nuts shall be 18-8 stainless steel with 5/8 inch NC threads. The lifter bar shall be of adequate design to provide a heavy bearing surface for all nuts. Bolt threads shall be fluorocarbon coated to prevent galling. Nylatron G.S. washers shall be provided for lubrication.

J. TAPPING VALVES

- 1. Valves for use with tapping sleeves shall meet or exceed all provisions of AWWA C509.
- 2. Valves for use with tapping sleeves shall be resilient seated wedge gate type and shall be designed for use with tapping equipment. The valves shall have non-rising stems and shall have an alignment ring to prevent misalignment with the tapping sleeves.
- 3. The valves shall close clockwise (right) and open counter clockwise (left), and shall be equipped with a standard 2-inch square operating nut. Valve outlets shall have a flanged by mechanical joint.

K. PIPE RESTRAINT:

- 1. Mechanical pipe restraining mechanisms for push-on or mechanical joints shall be used where indicated on the Drawings or as directed by the Engineer.
- 2. Restraining glands, tie rods, clamps or other components of dissimilar metals shall be protected against corrosion by the application of a suitable coating at the direction of the Engineer.
- 3. Mechanical restraints shall be sized for the working pressure plus surge allowance, or a test pressure of 200 psi, whichever is greater. Adequate factors of safety shall be employed.
- 4. Mechanical joint restraint shall be incorporated in the design of the follower gland and shall include a restraining mechanism which, when actuated, imparts multiple wedging action against the pipe, increasing its resistance as the pressure increases. Flexibility of the joint shall be maintained after burial. Glands shall be manufactured of ductile iron conforming to

ASTM A 536. Restraining devices shall be of ductile iron heat treated to a minimum hardness of 370 BHN. Dimensions of the gland shall be such that it can be used with the standard mechanical joint bell and tee-head bolts conforming to ANSI A21.11 and ANSI/AWWA C 153/A21.53. Twist-off nuts shall be used to ensure proper actuating of the restraining devices.

5. The minimum number of restrained joints required for resisting forces at fittings and changes in direction of pipe shall be determined from the length of restrained pipe on each side of fittings and changes in direction necessary to develop adequate resisting friction with the soil.
6. As a minimum, ductile iron pipe joints shall be restrained each side of the fitting for a continuous distance as shown on the Drawings. The lengths shall be increased by 25 percent for pipe that is encased in polyethylene. Where conditions do not provide adequate soil friction, the required lengths may be increased.
7. Bolts and nuts for restrained joints shall be corten, low alloy, high strength steel conforming to AWWA standards.
8. Restrained glands shall be MegaLug or approved equal.

L. VALVE BOXES:

1. All buried valves shall have cast iron two- or three piece valve boxes with cast iron covers.
2. Valve boxes shall be provided with suitable heavy bonnets and to extend to such elevation at or slightly above the finished grade surface. The barrel shall be one or two piece, screw type, having 5 ¼ inch shaft.
3. All valves shall have actuating nuts extended to within six inches of the top of the valve box cover.
4. Valve boxes shall be provided with concrete bases.

M. FIRE HYDRANTS

1. Fire hydrants must be in accordance with AWWA C502.
2. Hydrants should have 2 – 2 ½ “ outlet nozzles and 1 – 4 ½”, pumper nozzle with standard hose threads. Caps must be provided on nozzles and attached by chains.
3. Hydrants should be installed with break-away flange at base
4. Two operating keys shall be provided with each hydrant installed.

PART 3 - EXECUTION

3.1 PIPELINE TRENCH CONSTRUCTION

- A. Refer to Section Excavating and Backfilling for Utilities.

3.2 SETTING VALVE VAULTS

- A. The soil foundation beneath the precast unit shall be stabilized and compacted to 95 percent of the maximum density as determined by ASTM D1557 and ASTM D1556.
1. The precast valve vaults shall be carefully placed on the prepared foundation so as to be fully and uniformly supported in true alignment, making certain that the pipe can pass through on the designed line and grade.

2. Precast valve vaults shall be handled by lifting rings only.
3. Precast valve vaults and manholes shall be placed and aligned to provide vertical alignment with not more than 1/8 inch maximum tolerance for 5 feet of depth. The completed unit shall be rigid, true to dimensions and alignment.

3.3 LAYING POTABLE WATER MAINS

- A. Potable water mains shall be laid in accordance with the details shown on the Drawings and as specified herein.
 1. The trench bottom shall be graded to the proposed elevation of the pipeline and the bottom shaped to fit the lower quadrant of the pipe. Holes shall be excavated at each bell so the pipe will be uniformly supported along the entire length of the barrel only. Pipe bedding shall be in compliance with Section Excavation and Backfilling for Utilities and as specified herein.
 2. Pipe installation and jointing shall be in strict accordance with the pipe manufacturer's specifications and instructions for the type of pipe used and the applicable standards of the Utility.
 3. Any pipe having a defective joint, bell or spigot shall be rejected, removed from the work site and replaced with a sound unit.
 4. All pipe shall be installed to the homing mark on the spigot. On field cut pipe, the Contractor shall provide a homing mark on the spigot end in strict accordance with the manufacturer's recommendations.
 5. All pipe shall be retained in position so as to maintain alignment and joint closure until sufficient haunching and backfill has been placed to adequately hold the pipe in place.
 6. Foreign materials shall be prevented from entering the pipe while pipe is being placed in the trench. No debris, tools, articles of clothing or other materials shall be placed in the pipe at any time.
 7. At all times when pipe laying is not in progress for ten (10) minutes or more, the open ends of the pipe shall be closed by a watertight plug or other approved means to insure that absolute cleanliness is maintained inside the pipe at all times
 8. Laying conditions for potable water systems shall be in accordance with ASTM D746.
 - a. Ordinary bedding conditions, having a load factor of 1.5 shall be used for 16 inch diameter pipe and smaller.
 - b. First Class bedding conditions, having a load factor of not less than 1.5 shall be used for 18 inch to 30 inch pipe.
 - c. Pipe 36 inches and larger shall have first class bedding with a load factor of not less than 1.9.

3.4 JOINTING POTABLE WATER MAINS

- A. Pipe installation and jointing shall be in strict accordance with the pipe manufacturer's specifications and instructions for the type of pipe used and the applicable standards of the Utility. Joints shall be in strict accordance with AWWA C600, latest revision.
- B. The Contractor shall take all reasonable precautions to provide assurance that the interior of the pipe and the jointing seal shall be free from sand, dirt, trash or other foreign material before installation in the line. Any pipe or fitting that has been installed containing dirt or other detrital material shall be removed, cleaned and relaid. Extreme care shall be taken to keep the bells of

the pipe free from sand, dirt or rocks so that the joint may be properly assembled without over stressing the bells.

- C. All pipe shall be installed to the homing mark on the spigot. When field cutting of pipe is required, cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with push-on bell shall be beveled to conform to the manufacturers spigot end. Care shall be taken to prevent damage to linings.
- D. Deflection at pipe joints shall not exceed one half (1/2) the maximum pipe deflection recommended by the pipe manufacturer. If at any time joint deflections exceed one half (1/2) the manufacturer's maximum recommended pipe deflections, an appropriate fitting shall be used.

3.5 BACKFILLING, COMPACTION AND TESTING

- A. Refer to Section Excavation and Backfilling for Utilities.
- B. The Contractor shall not perform any backfilling operations other than those that are necessary to hold the pipe in place until soil test samples have been taken, locations recorded, the pipeline tested, inspected and released for backfilling.

3.6 CONNECTIONS FROM NEW TO EXISTING WATER MAINS

- A. No connections will be allowed from new to existing potable water mains not shown on the Drawings without written approval from the Owner and utility owner, as applicable.
 - 1. Approval will be made only after a request form for alteration or connection has been submitted with approved plans.
 - 2. The use of fire hydrants by other than authorized persons is prohibited. The Owner may permit the use of water from a fire hydrant for construction or other purposes provided the applicant shall properly meet the conditions of these Specifications and as shown in the appropriate standard. The installation shall be under the supervision of a representative of the Owner.
 - 3. Valves shall not be operated by any person other than Owner's or utility owner's personnel, as applicable.

3.7 FLUSHING

- A. Foreign material left in the pipelines during installation often result in valve and fire hydrant seat leakage during hydrostatic pressure testing. The Contractor shall make every effort to ensure that lines are kept clean during installation.
- B. Thorough flushing is required prior to hydrostatic pressure testing; flushing shall be accomplished by partially opening valves and fire hydrants several times under actual line pressures with pipeline velocities of not less than 3.0 feet per second in the largest line size to be flushed.
 - 1. The pipelines shall be flushed full bore and shall not be less than three (3) times the total volume of the section being tested.

3.8 PRESSURE AND LEAKAGE TESTING:

- A. Hydrostatic pressure and leakage testing of water mains shall be performed by the Contractor in accordance with the latest jurisdiction having authority specifications. All testing shall be made using water. Air testing shall not be permitted.
1. The Contractor shall furnish all gauges, meters, pressure pumps, and all other equipment required to pressure test the main at no additional cost to the Owner.
 2. All sections which fail to meet the tests shall be repaired and the leakage eliminated, regardless of the total leakage as shown by the test.
 3. All lines which fail to meet the tests shall be repaired and retested as necessary until the test requirements are complied with, at no additional cost to the Owner or the Utility. All defective materials, pipes, valves, and appurtenances shall be removed and replaced at the Contractor's expense.
 4. If the Engineer agrees that further construction works are believed to have affected the integrity of a previously tested section, that section shall be re-tested at the Contractor's expense.
- B. The required pressure for the field hydrostatic pressure test shall be as follows.
1. The Contractor shall provide all temporary plugs and blocking necessary to maintain the required test pressure. Corporation cocks, service saddles, pipe risers and angle globe valves shall be provided at each dead-end in order to bleed air from the main. The cost of these items shall be included as part of the testing.
 2. The duration of the pressure test shall be a minimum of two (2) hours. The costs of all required items shall be included as part of the testing.
- C. TEST PRESSURE RESTRICTIONS:
1. Test pressures shall not exceed the pipe or thrust-restraint design.
- D. PRESSURIZATION OF THE LINES:
1. Each valved section of the pipe shall be slowly filled with water and pressurized to the specified test pressure based on the elevation of the lowest point of the line or section under test, and corrected to the elevation of the test gauge by means of a force pump connected to the pipe in a manner satisfactory to the Utility.
- E. AIR REMOVAL BEFORE TESTING:
1. Prior to applying the specified test pressure, all air shall be expelled from the pipe, valves and hydrants.
 2. If permanent air relief valves or air vents are not located at all high points, the Contractor shall install corporation cocks at such points so that all air can be expelled as the line is filled with water.
 3. After all air has been expelled from the line, the corporation cocks shall be closed and the test pressure applied.
- F. EXAMINATION UNDER PRESSURE:

1. All exposed pipe, fittings, valves, hydrants, joints, etc. shall be carefully examined during the test. Defective or damaged pipe, fittings, valves or other appurtenances that are discovered following the pressure test shall be repaired or replaced with sound material, and the test shall be repeated until satisfactory to the Utility.

G. ACCEPTANCE OF THE INSTALLATION:

1. Zero leakage is allowed for the entirety of the two-hour test.
2. If any test discloses leakage greater than the amount specified above, the Contractor shall, at his own expense, locate and make repairs as necessary until the leakage is within the specified allowance. All visible leaks shall be repaired regardless of the amount of leakage.

3.9 DISINFECTION OF POTABLE WATER PIPELINES

- A. Prior to placing the water system in service, all potable water pipelines shall be chlorinated by in accordance with AWWA C-651, latest edition "AWWA Standard for Disinfecting Water Mains".
- B. The Contractor shall notify the Utility not less than five (5) working days prior to commencement of disinfection of the lines and shall present his plan for chlorination to the Engineer for approval.
- C. The location of the sampling points and chlorination points shall be determined by the Engineer and shall include all locations referenced in the required permits. All taps for chlorination and sampling shall be uncovered and backfilled by the Contractor at no additional expense to the Owner.
- D. After the line has been tested and accepted, the corporation cocks shall be removed and plugged, or left in place at the discretion of the Utility. The Contractor shall repair any damage to pipe exterior coating prior to acceptance.
- E. General procedure for disinfection of potable water systems.
 1. Prevent contaminating materials from entering the water main during construction, repair or storage.
 2. Remove by flushing any detrital material that may have entered the water main during construction.
 3. Chlorinate any residual contamination that may remain in the lines through a tap at one end of the line.
 4. Flush chlorinated water from the main after the required minimum detention time of 24 hours.
 5. Determine the bacteriological quality of the water by laboratory examination in accordance with "Standard Methods For the Examination of Water or Wastewater" or AWWA Manual M12.
- F. FILLING AND CONTACT:
 1. When installation has been completed, and flushed clean, the Contractor shall fill the main with water from the existing water distribution system or other approved source of supply and the water mains shall be made to flow at a constant measured velocity no greater than 1.0 foot per second into the newly laid water main. The Contractor shall furnish a water

meter or other approved device for measuring the rate of flow at no additional cost to the Owner.

- a. At a point not more than 2.0 feet downstream from the beginning of the new main, the entering water shall be dosed with a 1.0 percent chlorine solution, fed at a constant rate, such that the water will have a free chlorine residual of not less than 25 mg/ℓ at the end of a 24-hour holding period.
- b. To assure that this concentration is provided, the Contractor shall provide testing services to measure the chlorine concentration at regular intervals, in accordance with the procedures described in the current edition of "Standard Methods For the Examination of Water or Wastewater", or AWWA Manual M12. Approved standard chlorine test kits may be used.
- c. The following table gives the amount of chlorine required for each 100-feet of pipeline of various diameters. Solutions of 1-percent may be prepared using sodium hypochlorite or calcium hypochlorite. (Note: Calcium hypochlorite requires one pound of CaCl₂ to 8 gallons of water to provide the required chlorine concentration.)

CHLORINE REQUIRED TO PRODUCE 25mg/L CONCENTRATION IN 100-FT. OF PIPE BY DIAMETER		
PIPE DIA. (INCHES)	100% CHLORINE (lbs./100 Feet Pipe)	1.0% CHLORINE SOLUTION (lbs. NaOCl/Gal.) Water)
4	0.013	0.16
6	0.030	0.36
8	0.054	0.65
10	0.085	1.02
12	0.120	1.44
16	0.217	2.60
24	0.411	4.90

- d. During the application of chlorine, valves shall be positioned and operated so that the strong chlorine solution in the main being treated will not flow into connecting water mains that are in active service.
- e. Chlorine application shall not cease until the entire main is filled with heavily chlorinated water. The chlorinated water shall be retained in the main for not less than 24 hours, during which time all valves, hydrants and appurtenances in the treated section shall be operated to insure complete disinfection. At the end of the 24 hour period, the treated water in all portions of the main shall have a residual of not less than 10 mg/ℓ of free chlorine.
- f. Hypochlorite solutions shall be applied to the water main using a gasoline powered or electrically powered chemical-feed pump designed for feeding chlorine solutions at a controlled rate of flow. Feed lines shall be of such material and strength as to safely withstand the corrosion caused by the concentrated chlorine solutions and the pressures created by the pumps. All connections shall be checked for tightness before solution is applied to the main.

G. FINAL FLUSHING:

1. After the 24-hour retention period, the heavily chlorinated water shall be flushed from the main until the chlorine residual measurements show that the concentration in the water does not exceed 3.0 mg/l, but is not less than 0.5 mg/l.

H. DISPOSING OF HEAVILY CHLORINATED WATER :

1. Heavily chlorinated water shall not be discharged into lakes, ponds, reservoirs, canals or streams. The environment to which the chlorinated water is to be discharged shall be inspected and approved by the Utility prior to discharge of chlorinated effluent. If there is any question that the chlorinated discharge will cause damage to the environment, then a dechlorinating agent shall be applied to the water to be wasted to neutralize the chlorine residual remaining in the water.
2. The chlorine residual of water being disposed of shall be neutralized by treating with one of the chemicals listed in the following table:

POUNDS OF CHEMICALS REQUIRED TO REDUCE AND NEUTRALIZE VARIED RESIDUAL CHLORINE CONCENTRATIONS IN 100,000 GALLONS OF WATER. *				
RESIDUAL CHLORINE (mg/□)	SULFUR DIOXIDE (SO ₂)	SODIUM BISULFATE (NaHSO ₃)	SODIUM SULFITE (Na ₂ SO ₃)	SODIUM THIOSULFATE (Na ₂ SO ₃ 5H ₂ O)
1	0.8	1.2	1.4	1.2
2	1.7	2.5	2.9	2.4
10	8.3	12.5	14.6	12.0
50	41.7	62.6	73.0	60.0

*With the exception of chlorine residual, in mg/l, or P.P.M., all amounts shown above are in pounds.

3. STANDARD CONDITIONS:

- a. After final flushing and before the water main is placed in service, Contractor shall arrange for samples to be collected from the end of the line and shall have them tested for bacteriological quality in accordance with "Standard Methods For the Examination of Water and Wastewater", and shall show the absence of chloroform organisms. A standard plate count shall be required.
- b. Sampling: At least two samples shall be collected from the new main and two from each branch. In the case of extremely long mains (not greater than 1000 linear feet), it is required that samples be collected along the length of the line as well as at its end. The total number of samples and the locations of sampling points shall be as directed by the Engineer, all regulatory agencies as well as the Utility.

- c. Special Conditions: If, during construction, trench water has entered the main, or if in the opinion of the Engineer, excessive quantities of dirt and debris have entered the main, bacteriological samples shall be taken at intervals of not more than 200 feet and shall be identified by station or location. Samples shall be taken of water that has been standing in the main for at least 16 hours after final flushing has been completed.
- d. Sampling Procedures: Samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate as required by "Standard Methods for the Examination of Water and Wastewater". Hoses and fire hydrants shall not be allowed in the collection of bacteriological samples. Approved sampling points shall be corporation cocks with gooseneck assemblies and terminal blow-off/sampling tap only.

J. RECHLORINATION

- 1. Should the initial disinfection fail to produce satisfactory bacteriological samples, the main shall be rechlorinated by the continuous feed method until satisfactory results are obtained.
 - 2. Should positive bacteriological samples continue to be recorded, the situation shall be evaluated by the Engineer to determine corrective action, and daily samples recorded.
 - 3. All retesting shall be at the expense of the Contractor.
- K. Prior to placing the water system in service, the water system shall be cleared for use, in writing, by the Design Engineer and Owner.

END OF SECTION 331110

SECTION 333313 - SANITARY SEWER GRAVITY SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Gravity sanitary sewerage collection system including:

1. Gravity sanitary sewer pipe.
2. Manholes.
3. Cleanouts.
4. Alteration of existing sewerage structures.

1.2 QUALITY ASSURANCE

A. Tests and inspections:

1. Procedure: In accord with Division 1.
2. Required tests:
 - a. After alignment tests have been completed, and before flows are allowed in the line, conduct leakage tests.
 - b. Test entire system for exfiltration in presence of engineer. Limit leakage to 100 gal. per inch of pipe dia. per mile of length per 24 hr..
 - c. Limit leakage to stated maximum limit, except that an allowance of an additional 10% of gallonage will be allowed for each additional 2 ft. of head over a basic 2 ft. minimum above all pipe soffits.
 - d. Pay for all leakage tests and required repairs and reconstruction.

B. Reference specifications and standards:

1. AASHTO: Specifications for Highway Bridges.
2. AASHTO: M198 Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets
3. ASTM: A48 Gray Iron Castings.
4. ASTM: A74 Cast Iron Soil Pipe and Fittings.
5. ASTM: A746 (ANSI/AWWA C151/21.51) Ductile Iron Pipe.
6. ASTM: C94 Ready-Mix Concrete.
7. ASTM: C150 Portland Cement.
8. ASTM: C443 Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
9. ASTM: C478 Precast Reinforced Concrete Manhole Sections.
10. ASTM: C923 Watertight Resilient Connectors for Manhole to Pipe Seal.
11. ASTM: D1248 Polyethylene Plastics Molding and Extrusion Materials.

12. ASTM: D1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 13. ASTM: D2122 Determining Dimension of Thermoplastic Pipe and Fittings.
 14. ASTM: D2321 Underground Installation of Flexible Thermoplastic Sewer Pipes.
 15. ASTM: D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
 16. ASTM: D3034 Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 17. ASTM: D3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
 18. ASTM: F477 Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 19. ANSI/AWWA: C105/A21.5 Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids.
 20. ANSI/AWWA: C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 21. ANSI/AWWA: C150/A21.50 Thickness Design of Ductile-Iron Pipe.
 22. ANSI/AWWA: C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast for Water or Other Liquids.
- C. Allowable tolerances for manhole frames:
1. Horizontal location: Within ± 3 in., in any direction, of horizontal location indicated on Drawings.
 2. Vertical alignment: Not greater than 1/8 in. maximum tolerance for 6 ft. of depth.

1.3 SUBMITTALS

- A. Procedure: In accord with Division 1 Specifications.
- B. Product data: Manufacturer's detailed technical materials, fabrication, and installation data, including technical bulletins, drawings, guides, and manuals, as applicable to the work of this Project.
- C. Certifications: Manufacturer's certification that pipe and fittings have been inspected and tested at the point of origin, and are in compliance with specified requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Pipe and fittings:
 1. Polyvinyl chloride (PVC) pipe and fittings for mainlines 15 in. and smaller: Conform to ASTM D3034, SDR 35.
 - a. Manufacture pipe from approved, Type 1, Grade 1, PVC 12454-C conforming to ASTM D1784 and meeting requirements of ASTM D2122 and ASTM D2412.
 - b. Pipe shall have integral wall thickened bells or extruded couplings with gasket seals. Solvent weld joints will not be permitted.

- c. Pipe joints shall be gasket push-on type complying with ASTM D3212 and ASTM F477.
 - d. Pipe shall be UL/FM approved.
 - e. Fittings shall conform to the same specifications as pipe in which they are to be installed.
 - f. Pipe shall be identified on the exterior of the pipe with the following information:
 - (1) Nominal pipe size and o.d. base.
 - (2) Material code designation number (12454C).
 - (3) Dimension ratio number (SDR 35).
 - (4) Pipe Stiffness Designation (PS46).
 - (5) ANSI/ASTM Designation (D3034).
 - (6) Pipe manufacturer's name and production code.
 - g. Acceptable manufacturers:
 - (1) Clow.
 - (2) H and W.
 - (3) Certainteed.
 - (4) J-M Manufacturing Company, Inc.
 - (5) Robintech.
2. Ductile iron pipe (DIP) and fittings: Conform to ANSI/AWWA C151/A21.51.
- a. Pipe shall have a minimum tensile strength of 60,000 psi with a minimum yield strength of 42,000 psi.
 - b. Pipe thickness shall be in accord with Table 50.12, ANSI/AWWA C150/A21.50, and shall be Class 50.
 - c. Ductile iron pipe and fittings shall have a minimum of 40 mils thick polyethylene lining in accord with ANSI/AWWA C151/A 21.51 and ASTM D1248. Polyethylene lining shall have sufficient carbon black added to resist ultraviolet rays during storage. Protecto 401 Ceramic Epoxy Lining (by Indurall Coatings, Inc., Birmingham, AL) may be used in lieu of polyethylene lining.
 - d. Pipe shall be supplied in lengths not in excess of a nominal 20 ft., and shall be single gasket, push-on joints (American Fastite or Owner-approved equivalent) conforming to ANSI/AWWA C111/A21.11.
 - e. Pipe shall have a minimum 1 mils bituminous coating on pipe exterior in accord with ANSI/AWWA C151/A21.51.
 - f. Polyethylene encasement, where required, shall be in accord with ANSI/AWWA C105/21.51. Polyethylene tubing shall conform to ASTM D1248.
 - g. Acceptable manufacturers:
 - (1) U.S. Pipe.
 - (2) American.
 - (3) Clow.
3. Cast iron soil pipe and fittings: Conform to ASTM A74, service weight bell and spigot pipe with the following acceptable gasket types:

- a. Dual Tite.
 - b. Rich-Seal.
 - c. Ty-Seal.
- B. Precast concrete manhole sections: Precast manhole base sections, barrel sections, eccentric or concentric cone sections, and grade rings shall conform to ASTM C478.
 1. Concrete for manhole sections shall be Class A concrete with a compressive strength of 4,000 psi at 28 days conforming to ASTM C94, using ASTM C150 Type II Portland cement.
 2. Cure manhole sections by an approved method for a minimum of 4 days prior to painting and shall not be shipped for a minimum of 3 days after having been painted. Manhole sections shall not be shipped for a minimum of 7 days after removal from forms.
 3. Interior and mating surfaces shall have a protective coal tar epoxy coating having a minimum dry film thickness of 16 mils. The exterior surfaces shall have a protective coal tar epoxy coating with a minimum dry film thickness of 9 mils.
 - a. Coatings shall be applied by precast manufacturer in accord with coating manufacturer's recommendations.
 - b. Acceptable coating:
 - (1) Carboline (Kop-Coat) Bitumastic 300M.
 - (2) Karlee's Perma-Bar.
 - (3) Owner-approved equivalent.
 4. Clearly mark or impress date of manufacture of manhole sections and name or trademark of manufacturer on exterior of each precast section when form is removed and on interior after section has been painted.
 5. Cast precast manhole sections with tongue and groove joints, and sealed with Ramnek™ sealant by the T.K. Snyder Company of Houston, TX or Owner-approved equivalent. Joint sealant shall meet or exceed all requirement of Federal Specifications SS-S-210A and AASHTO M198. Do not use rubber ring manhole joint seals.
 6. Precast manhole bases with invert channels cast or formed directly into standard precast concrete manhole bases shall be used except at junctions with existing sewer mains.
 - a. Bench shall be formed smooth and brush finished, and shall slope smoothly and evenly downward at a minimum slope of 3/4 in. per ft. from manhole wall to flow channel. Size and shape of flow channel shall conform to lower 8/10 dia. of inlets and outlets.
 - b. When flow line directional changes occur which exceed 45°, an additional flow line drop of 1/10 ft. across manholes shall be provided.
 - c. Precast manhole base units shall be of the Moore Base design or Tru-Contour design.
 7. Acceptable manufacturers:
 - a. Atlantic Precast Concrete, Inc., Sarasota, FL.
 - b. Mack Concrete Industries, Inc., Apopka, FL.
 - c. Southern Precast, Inc., Alachua, FL.
 - d. Taylor Precast, Inc., Deland, FL.

8. Shallow or flat top manholes, where depth of cover is less than 4 ft., shall have vertical walls with a flat precast top slab. Precast top slab shall be capable of supporting the overburden plus a live load equivalent to H-20 loading in accord with AASHTO Specifications for Highway Bridges.
 9. Do not use brick manholes.
 10. Manholes receiving force main discharges shall have a PVC or fiberglass liner.
 11. Precast manhole sections shall have a wall thickness conforming to ASTM C478.
 12. Manhole base sections shall be not less than 8 in. thick and shall be reinforced with No. 5 steel reinforcing bars spaced at 9 in. o.c. each way and shall have No. 4 steel reinforcing steel bars around each opening.
 13. Precast concrete shall be wet cast. Do not use dry casting or low slump concrete.
 14. All precast concrete manhole bases shall have a minimum of three proper lifting loops in the base slabs.
 15. Do not use penetrating lifting holes in any structure. Where non-penetrating lifting holes are approved, their use will not be permitted within 8 in. of joint or pipe penetration.
 16. Where pipes enter or exit manholes, a neoprene rubber connector shall be used to provide a resilient watertight connection for the penetration into manhole. Watertight resilient manhole connectors shall conform to ASTM C923.
 - a. Resilient connector shall be Kor-N-Seal molded neoprene boot by National Pollution Control Systems, Inc. of Nashua, NH or A-Lok resilient pipe connector by A-Lok Products, Inc. of Tullytown, PA, or Owner-approved equivalent.
 - b. Resilient pipe connectors shall be supplied and installed by manufacturer of precast products.
 17. Precast concrete grade rings for manhole adjustment shall conform to ASTM C478. Grade rings shall be a minimum of 2 in. thick, a maximum of 5 in. thick, and be reinforced with No. 6 gauge or thicker reinforcing wire. Do not use brick for manhole adjustment.
 18. Drop manholes shall be provided where pipes enter manhole at an elevation 24 in. or more above invert of receiving manhole.
 19. Pipe penetrations into manhole walls shall be precast or corebored by mechanical means. Do not use concrete chisels or hand tools.
 20. Manholes shall be precast units with integral slab and lower ring. Cast-in-place base slab with precast ring walls shall not be approved, except at junctions with existing storm sewers, where saddle manholes are specified, or at locations as directed by Owner.
- C. Manhole frame, cover, and adjustment rings: Gray iron castings conforming to ASTM A48 Class 30 and ASTM C478.
1. Lifting or pick holes shall be non-penetrating.
 2. Frames and covers shall be traffic bearing and capable of supporting H-20 loadings in accord with AASHTO Specifications for Highway Bridges.
 3. The manhole frame, cover, and adjustment rings shall be as indicated on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION/PERFORMANCE

- A. Excavating, trenching, backfilling, and compacting: In accord with Section Excavating and Backfilling.
- B. Setting manholes:
 - 1. Carefully place precast manhole base section on prepared foundation so as to be fully and uniformly supported in true alignment, ensuring that penetrating pipes can be installed at proper line and grade.
 - a. Handle precast manhole units by lifting rings only.
 - b. Place and adjust first precast section to true grade and alignment. Install inlet pipes to form an integral watertight unit. Uniformly support sections upon the base structure, and without any bearing directly on penetrating pipes.
 - c. Place and align precast manholes to provide horizontal location and vertical elevations as indicated on Drawings. Installed manhole shall be rigid, true to dimensions and alignment, and watertight.
 - 2. Fully bed manhole frame and cover in mortar, with precast concrete grade rings placed between manhole cone and manhole frame.
 - a. Precast concrete grade rings shall conform to the specifications for precast concrete sections as designated in ASTM C478.
 - b. Precast concrete grade rings shall have a minimum depth of 2 in. and a maximum depth of 5 in.
 - c. Precast concrete grade rings shall not be used for more than 19 in. of vertical adjustment.
 - d. Do not use brick for manhole adjustment.
- C. Pipe laying: Lay pipe as indicated on Drawings, as specified herein, and in compliance with applicable portions of ASTM D2321.
 - 1. Grade trench bottom to indicated elevation of pipeline and shape bottom to fit lower quadrant of pipe. Excavate holes at each bell hub such that pipe will be uniformly supported along entire length of barrel only.
 - 2. Pipe installation and jointing shall be in accord with pipe manufacturer's specifications and instructions for type of pipe used and applicable requirements specified herein. All pipe having a defective joint, bell, or spigot is unacceptable, shall be rejected, removed from site, and replaced with an acceptable unit.
 - 3. Commence pipe laying in finished trench at lowest point, or from a point designated by Owner, and lay upgrade from point of connection with all bell ends forward.
 - 4. Install pipe to homing mark on spigot. On field cut pipe, provide a homing mark on spigot end in accord with manufacturer's recommendations.
 - 5. Maintain pipe alignment and joint closure until sufficient haunching and backfill is in place to adequately hold pipe in position.
 - 6. Prevent foreign materials from entering pipe while it is being placed in trench. Do not place debris, tools, articles of clothing, or other materials in pipe at any time.
 - 7. As each length of pipe is placed in trench, assemble joints and bring pipe to intended line and grade. Bed and secure pipe in place.

8. When pipe laying is delayed for 10 min. or more, close open ends of pipe using a watertight plug or other approved means to ensure that absolute cleanliness is maintained inside pipe.
 9. At penetrations of manhole and similar structures, smoothly cut penetrating ends of pipe parallel to interior surface of structure. Maximum interior protrusion of pipe shall be the minimum necessary for proper sealing of pipe connection to structure. Use resilient connector when indicated on Drawings.
- D. Pipe jointing:
1. Pipe installation and jointing shall be in accord with pipe manufacturer's specifications and instructions for type of pipe used and applicable requirements specified herein.
 2. Ensure that interior of pipe and jointing seal is free of sand, dirt, trash, or other foreign materials before installation. All pipe or fitting that has been installed containing dirt or other deleterious material shall be removed, cleaned, and relaid. Extreme care shall be taken to keep bells of pipe free from sand, dirt, or rocks so that joints may be properly assembled without overstressing bells.

3.2 FIELD QUALITY CONTROL

- A. Alignment: Inspect sanitary sewerage lines to determine if displacement of pipe has occurred during backfilling and compaction.
- B. Correct, at no additional cost, sections of piping that are deficient in material, alignment, grade, or joints.

END OF SECTION 333313

SECTION 334000 - STORM SEWER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items necessary for the proper installation of the storm sewerage system.
- B. Storm sewerage system includes:
 - 1. Storm drains.
 - 2. Catch basins.
 - 3. Manholes.
 - 4. Alteration of existing drainage structures.
 - 5. Retention trench and underdrains.

1.2 DESCRIPTION OF WORK

- A. Extent of storm sewage systems work is indicated on drawings and schedules, and by requirements of this section.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of storm sewage system's products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with storm sewage work similar to that required for project.
- C. Codes and Standards:
 - 1. Plumbing Code Compliance: Comply with applicable portions of Florida Department of Transportation Standard Specifications for Road and Bridge Construction, 2014 Edition (FDOT 2014), pertaining to selection and installation of storm sewage system's materials and products.
- D. Environmental Compliance: Comply with applicable portions of the Environmental Impact Analysis applicable Water Management District and Local Storm Water Management Regulations

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for storm sewage system materials and products.
- B. Shop Drawings: Submit shop drawings for storm sewage systems, showing piping materials, size, locations, and inverts. Include details of underground structures, connections, and manholes.

Show interface and spatial relationship between piping and proximate structures.

- C. Record Drawings: At project closeout, submit record drawings of installed storm sewage piping and products, in accordance with requirements of Division-1.
- D. Maintenance Data: Submit maintenance data and parts lists for storm sewage system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Division-1.

1.5 REFERENCES

- A. ASTM: C76 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- B. ASTM: C443 Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
- C. ASTM: C478 Precast Reinforced Concrete Manhole Sections.
- D. ASTM: C969-94 Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
- E. ASTM D-5034, ASTM D-5035, and ASTM D-3786, latest revisions: Filter Fabric Properties.

PART 2 - PRODUCTS

2.1 PIPES AND PIPE FITTINGS

- A. General: Provide pipes of one of the following materials, of weight/class indicated. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated.
 - 1. Cast-Iron Soil Pipe: ASTM A 74, hub and spigot ends, service weight unless otherwise indicated.
 - a. Fittings: Cast-iron hub and spigot complying with ASTM A 74; lead/oakum caulked joints, or compression joints with rubber gaskets complying with ASTM C 564.
 - 2. Reinforced Concrete Pipe: FDOT 2014 Section 556, Class III (of ASTM C76).
 - a. Fittings: Reinforced concrete, same strength as adjoining pipe, tongue-and-groove gasketed joints complying with ASTM C 443.
 - b. Rubber Gaskets: FDOT 2014 Section 942.
 - 3. Polyvinyl Chloride (PVC) Sewer Pipe: or ASTM D 3034, Type PSM, SDR 35.
 - a. Fittings: PVC, ASTM D 3034, elastomeric joints complying with ASTM D 3212 using elastomeric seals complying with ASTM F 477.
 - 4. High Density Polyethylene (HDPE) Pipe
 - a. HDPE Pipe shall be produced from PE3408 pipe grade polyethylene resins, the resins shall meet the engineering requirements as defined by ASTM standard D-1248 for a

- Type III, Class C, Category 5, Grade P34 material.
- b. Storm drainage piping shall be N-12, HDPE pipe as manufactured by Advance Drainage Systems, Inc., or approved equal. Pipe shall be corrugated with an integrally formed smooth interior. Pipe shall conform to AASHTO classification "Type S;" and AASHTO M252 and M294 for test methods, dimensions and markings.
5. Corrugated Steel Pipe and Pipe Arch: FDOT 2014 SPECIFICATIONS 943, bituminous coated both sides.
 6. Corrugated Steel Pipe and Pipe Arch: Aluminum coated (Aluminized Type II): AASHTO M274 and AASHTO M36.
 7. Coupling/Corrugated Steel Pipe and Pipe Arch: AASHTO M36 with rubber or neoprene gaskets, FDOT 2014 SPECIFICATIONS 430-8.1 (all pipe).
 8. Corrugated Aluminum Pipe and Pipe Arch: AASHTO M196 and AASHTO M211.
 9. Corrugated Aluminum Pipe with Perforations (360 degree): AASHTO M196 and M211, ASTM B 209 for Alloy Alclade 3004-H34.
 10. Coupling/Corrugated Aluminum Pipe and Pipe Arch: AASHTO M196 and AASHTO M211 with asphaltic mastic sealant (performed plastic material), (all pipe).
 11. Filter Fabric: Spun bound polypropylene, "TYPAR," as manufactured by DuPont, Style 3401.
 12. Bituminous Coating: AASHTO M190.
 13. Non-shrinking Mortar: Embeco 167 or approved equal.
 14. Precast Circular Manholes: Precast reinforced concrete per C 478, except wall thickness shall be 1 inch per foot of inside diameter plus 1 inch but 5 inch minimum. All openings shall have minimum steel hoop of #4 wire. Cement shall be Portland Type II. Provide a 6-inch lip on the base.
 15. Concrete: FDOT 2014 Section 346 (except no pozzolon), 4, 6, 9, 10, 11, 12 and 13. Class II or Class III with minimum 28 day compressive strengths of 3400 psi and 5000 psi, respectively. Use Type II Portland Cement.
 16. Reinforcement: FDOT 2014 Section 415 (ASTM A615, Grade 60).
 17. Curing: FDOT 2014 SPECIFICATIONS 925.
 18. Brick: ASTM C 32, grade MC (hard brick).
 19. Mortar: For brick sections of manholes mix one (1) part Portland Cement Type II and three (3) parts of sand per FDOT 2014 Section 902-2.2. For mortar plaster use one (1) part cement, two (2) parts sand.
 20. Manhole Joint Sealer: Pre-formed plastic joint sealer per Federal Specification SS-S-00210 (GSA - PSS), "Ram-Nek" as manufactured by the K.T. Snyder Co., Inc., or approved equal, or Portland Cement mortar, 1/2 inch minimum thickness.
 21. Manhole Frame & Cover: Gray cast iron per ASTM A 48, Class 30 without perforations and suitable for addition of cast iron or steel rings for upward adjustment of top. The word "STORM" shall be cast into the face of the cover equal to that shown in the Standard Detail Drawings in 1-1/2 to 2 inch letters raised flush with the top of the cover. Frame and cover shall be approved equal to U.S. Foundry and Manufacturing Corp. No. 430 (old No. 32 with Type G cover). Frames and covers shall have machine ground seats and have a coating of coal tar pitch varnish.
 22. Where prefabricated adjustable frames are called for in the Drawings, they shall be approved equal to U.S. Foundry No 560 (old No. 23 with Type G Cover) and comply with the above requirements.
 23. Inlet Gratings and Frames: Structural steel, FDOT 2014 Section 425-3.2, U.S. Foundry or equal; Gray Cast Iron, FDOT 2014 Section 962-4.1.
 24. Bitumastic: Koppers No. 300M, or approved equal.

25. Non-shrink Mortar: Embeco 167 or approved equal.
26. Forms: Forms shall be either wood or metal, externally secured and braced when feasible, substantial and unyielding, and of adequate strength to contain the concrete and the additional force of vibration consolidation without bulging between supports and without apparent deviation from neat lines, contours and shapes shown in the Drawings.

2.2 UNDERDRAINS

A. Filter Fabric:

1. All underdrain pipe shall be encased in filter fabric sock per FDOT Standard Specifications for Road and Bridge, 2014 Edition. Section 948-8.
2. Filter Fabric for use in underdrains shall be in accordance governing jurisdiction's specifications.

B. Underdrain Aggregate:

1. Aggregate for underdrain material shall be clean, flowable, well drained sand with less than 5% by weight passing the 200 sieve.

C. Corrugated Polyethylene Pipe and Fittings

1. Corrugated polyethylene tubing for use as underdrain shall conform to the requirements of AASHTO M 252, latest edition. Polyethylene tubing shall be delivered in 20 foot lengths (minimum) and shall be fitted, prior to installation, with a filter fabric wrap as described in 2.01A of this Section. Perforations in the pipe shall be punched rather than slit in order to provide positive openings in the pipe.
2. The fittings shall not reduce or impair the overall integrity or function of the pipe line. Couplings shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. Only fittings supplied or recommended by the pipe manufacturer shall be used.

D. Clean-outs

1. Clean-outs for the underdrain system shall be furnished, as shown in the plans, and shall conform to the applicable details on the Drawings.

2.3 TRENCH DRAINS

- A. Trench Drains to be installed in accordance with manufacturer's recommendations.
- B. Approved Manufacturers: Zurn, ACO, ABT, or approved equal.
- C. Trench drains may be concrete, concrete polymer or plastic. Steel or aluminum trench drains will not be permitted.
- D. Grates are to be selected by landscape architect.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE AND PIPE FITTINGS

- A. General: Trench excavation and backfill, including sheeting and bracing dewatering, foundation and bedding and furnishing and disposal of materials shall be as specified in Section 312334 of these Standard Specifications, "EXCAVATING AND BACKFILLING FOR UTILITIES" with any additional requirements included herein.
- B. All pipe joints shall be wrapped in filter cloth fabric. Fabric shall be centered on joint and minimum of 24" wide with minimum 12" of overlap on the circumference.
- C. Laying Pipe: Pipe shall be laid "in the dry" true to the lines and grades given with hubs up and tongue fully inserted into the hub. Provide recesses at each joint as required to establish continuous loading conditions along the pipe barrel. Maintain a clean interior as the work progresses. Adequate filtering methods shall be provided to prevent flushing debris and sediment into any receiving waters.
- D. Round Concrete Pipe: ASTM C443-85a.
 - 1. Seal all joints with round rubber gaskets. The gasket and the surface of the joints must be clean and free of grit, dirt and other foreign matter. To facilitate closure of the joint, apply a vegetable soap lubricant immediately prior to closing. Do not apply mortar, joint compound, or other filler which will restrict the flexibility of the gasket joint.
 - 2. Deviations from true alignment or grade, which result in a displacement from the normal position of the gasket of as much as 1/4 inch, or which produce a gap exceeding 1/2 inch between sections of pipe for more than 1/3 of the circumference of the inside of the pipe, will not be acceptable and where such occur the pipe shall be re-laid without additional compensation. Where minor imperfections cause a gap greater than 1/2 inch between pipe sections, the joint will be acceptable provided the gap does not extend more than 1/3 the circumference of the inside of the pipe.
- E. Oval Concrete Pipe: Seal all joints with round rubber gaskets. The gasket and the surface of the joints must be clean and free of grit, dirt and other foreign matter. To facilitate closure of the joint, apply a vegetable soap lubricant immediately prior to closing. Do not apply mortar, joint compound, or other filler which will restrict the flexibility of the gasket joint.
- F. Cast-Iron Soil Pipe: Install in accordance with applicable provisions of CISPI "Cast Iron Soil Pipe & Fittings Handbook."
- G. Plastic Pipe: Install in accordance with manufacturer's installation recommendations, and in accordance with ASTM D 2321.
- H. Cleaning Piping: Clear interior of piping of dirt and other superfluous material as work progresses. Maintain swab or drag in line and pull past each joint as it is completed.
 - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 - 2. Place plugs in ends of uncompleted conduit at end of day or whenever work stops.
 - 3. Flush lines between manholes if required to remove collected debris.
- I. Joint Adapters: Make joints between different types of pipe with standard manufactured adapters and fittings intended for that purpose.

- J. Closing Abandoned Utilities: Close open ends of abandoned underground utilities which are indicated to remain in place. Provide sufficiently strong closures to withstand hydro-static or earth pressure which may result after ends of abandoned utilities have been closed.
 - 1. Close open ends of concrete or masonry utilities with not less than 8 inches thick brick masonry bulkheads.
- K. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.
 - 1. Make inspections after lines between manholes, or manhole locations, have been installed and approximately 2 feet of backfill is in place, and again at completion of project.
 - 2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, correct such defects, and reinspect.
- L. Lay pipe upgrade with the bell end of pipe section upgrade.
- M. During installation, close open ends of pipe with temporary, water-tight plugs to prevent earth, water and other material from entering the pipe.

3.2 INSTALLATION OF UNDERDRAINS

- A. The trench shall be excavated carefully, to such depth as is required to permit the pipe to be laid to the grade desired, and to the dimensions shown on the Drawings.
- B. The pipe with filter fabric sock installed, shall be bedded firmly in the filter aggregate to the correct line and grade. Installation of the pipe shall be in accordance with ASTM Recommended Practice D2321. The upper end of the run of pipe shall be plugged to prevent any filter aggregate from entering the pipe. Lateral connections shall be made with special fittings, as required.
- C. After the pipe has been laid to grade, the pipe shall be firmly held in place by mechanical means while the filter aggregate is placed to a maximum height of five (5) inches ☐ one inch (compacted) above the top of the pipe. After the first lift is compacted to the satisfaction of the Engineer, additional aggregate shall be placed and compacted and the remainder of the trench shall be backfilled in lifts with underdrain aggregate. The minimum density of the compacted filter aggregate be 95 percent of the standard density as determined by AASHTO T99 (Method A). The excavation of the trench, the placement of the filter fabric, the installation of the pipe and the placement and compaction of the first lift of filter aggregate shall be accomplished in a single continuous operation.

3.3 STORM SEWER STRUCTURES

- A. Fabrication: All structures shall be constructed as shown in the Drawings or Standard Detail Indexes per FDOT SPECIFICATIONS Roadway and Bridge Design Standards 2014 Edition. Structures may be precast concrete or poured in place concrete.
- B. Foundation: Compact the soil beneath the structure to 95 percent of maximum (AASHTO T-180) density. Additionally provide 9 inches of gravel beneath structures with precast bases.

- C. Manhole Base: Construct per Standard Detail Drawings with Type II Portland Cement concrete, Class II or cast as an integral part of the precast section. If the base is poured, form a groove in the base with an accurate manhole ring, shape with a wood float and finish with a hard steel trowel prior to setting. The base shall set a minimum of 24 hours before the manhole construction proceeds. Precast base shall have a minimum of three lifting hooks set in. The base shall extend 6 inches on all sides of the structure.
- D. Joints - Precast Structures: Structures without precast integral bottoms shall be set in a bed of mortar to make a watertight joint at the base. Join precast sections with a minimum mortar thickness of 1/2 inch, maximum of 1 inch. Joint sealer may be used as an alternate.
- E. Structure Invert: the bottom of all drainage structures shall be filled with grout to the elevation of the lowest pipe invert entering/leaving the structure. Grout shall consist of a 3:1 sand-cement mixture, or any class concrete.
- F. Manhole Coating: Coat the exterior surface with one coat of Bitumastic at a minimum rate of 375 square feet per gallon, factory applied and "touched-up" in the field.
- G. Manhole Frames and Covers: Set manhole frames and covers to conform to the grades in the Drawings. Set all frames securely in a cement mortar bed and fillet. All covers shall be made flush with existing permanent surfaces except outside the limits of the traveled ways where they should be set approximately 0.2 foot above the existing ground unless otherwise noted in the Drawings.
- H. Manholes Watertightness: When tested by plugging all inlets and the outlet and filling the structure to within one foot of the cone section or top, with a minimum depth of 4 feet and maximum depth of 20 feet, the maximum allowable drop of the water surface shall be 1/2 inch per 15 minute interval. Contractor shall plug all leaks by method approved by the Engineer.
- I. Pipe Connections: Seal pipes into structure openings with non-shrinking mortar. Provide one joint immediately outside the structure wall. Openings into existing structures shall be cut with a power driven abrasive wheel or saw.

3.4 BACKFILLING

- A. General: Conduct backfill operations of open cut trenches closely following laying, jointing, and bedding of pipe, and after initial inspection and testing are completed.

3.5 FIELD QUALITY CONTROL

- A. Lamping: Lamp all sewers between manholes, and catch basins after the backfill has been compacted to determine that they are clear of debris and to the correct alignment. The concentricity of the lamp image received shall not vary in the vertical direction but may vary up to 20 percent in the horizontal direction.
- B. Inspection: Final visual inspection shall be made after all structures are raised to finished grade and the roadway installed. If the lines are unclean, clean-up and re-lamping shall be initiated. Contractor shall assist the engineer during this inspection.

END OF SECTION 334000

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