

# SCHRADERGROUP

## Volume 3

## DIVISION 21 – DIVISION 34

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Prepared for:

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New Facility Project:

**Bertie County 911 Communications**

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Issued for Permit:

April 6, 2026 ©



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Not Applicable

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

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Elastomeric hangers.
5. Snubbers.
6. Restraints - rigid type.
7. Restraints - cable type.
8. Restraint accessories.
9. Post-installed concrete anchors.
10. Concrete inserts.

- B. Related Requirements:

1. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

#### 1.3 DEFINITIONS

- A. Designated Seismic System: A fire-suppression component that requires design in accordance with ASCE/SEI 7, Ch. 13 and for which the Component Importance Factor is greater than 1.0.
- B. IBC: International Building Code.
- C. OSHPD: Office of Statewide Health Planning and Development (for the State of California).

#### 1.4 ACTION SUBMITTALS

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

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-load-restraint fitting and assembly.

3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-load-restraint component.
  4. 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 ICC-ES product listing UL product listing FM Approvals an evaluation service member of ICC-ES OSHPD an agency acceptable to authorities having jurisdiction.
  5. Annotate to indicate application of each product submitted and compliance with requirements.
  6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- 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. Refer to structural drawings S-001 for wind and seismic load information.
    - e. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
    - f. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" in "Performance Requirements" Article.
    - g. 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. Refer to structural drawing S-001 for wind and seismic load information.

## PART 2 - PRODUCTS

### 2.1 ELASTOMERIC ISOLATION PADS

#### A. Elastomeric Isolation Pads:

- 1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
- 2. Size: Factory or field cut to match requirements of supported equipment.
- 3. 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. Infused nonwoven cotton or synthetic fibers.
- 6. Load-bearing metal plates adhered to pads.
- 7. Sandwich-Core Material: Resilient and elastomeric.
  - a. Surface Pattern: Smooth, ribbed, or waffle pattern.
  - b. Infused nonwoven cotton or synthetic fibers.

### 2.2 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.

### 2.3 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.

## 2.4 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.

## 2.5 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.
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch (6-mm) air gap, and minimum 1/4 inch (6 mm) thick.

## 2.6 RESTRAINTS - RIGID TYPE

### A. 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.

## 2.7 RESTRAINTS - CABLE TYPE

### A. Seismic-Restraint Cables: ASTM A1023/A12023M 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.

- B. Restraint cable assembly with 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.

## 2.8 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 restraints 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.

## 2.9 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 for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:
  - 1. 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 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.
- 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.

## 2.10 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 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation, wind control, and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application 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.

### 3.3 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 snubbers on fire-suppression 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 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. 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 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," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for piping flexible connections.

### 3.5 ADJUSTING

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

### 3.6 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. 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.
  8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.

- F. Prepare test and inspection reports.

END OF SECTION 201548

## SECTION 21 13 13 - WET-PIPE SPRINKLER 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. Pipes, fittings, and specialties.
  - 2. Specialty valves.
  - 3. Sprinklers.
  - 4. Alarm devices.
  - 5. Pressure gages.

- B. Related Requirements:

- 1. Section 211119 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
  - 2. Section 2846211 "Addressable Fire-Alarm Systems"

#### 1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

#### 1.4 ACTION SUBMITTALS

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

- 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

- 1. Include plans, elevations, sections, and attachment details. Submit working plans in accordance with NFPA 13 including hydraulic calculations. Submit shop drawings with product data. Shop drawings shall be prepared by a certified engineering technician, NICET Level III or IV.
  - 2. Shop drawings shall indicate the ceiling grid, lighting fixtures, HVAC ductwork, air devices, etc.
  - 3. Include diagrams for power, signal, and control wiring.

- C. Qualification Data: For qualified Installer and Sprinkler System Designer.

- D. Welding certificates.
- E. Field Test Reports:
  - 1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Above-ground Piping."
- F. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

#### 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. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

#### 1.7 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.
  - 2. Designer Responsibility: Preparation of working plans (shop drawings and product data), calculations, and field test reports by a NICET Level III or IV Technician or by a registered professional engineer
- B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
  - 1. NFPA 13.

- B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- C. Delegated Design: Engage a qualified professional engineer or NICET technician, as defined herein to design wet-pipe sprinkler systems.
  - 1. A new NFPA 291 compliant water flow test shall be performed as a basis for sprinkler system design. A flow test was performed on June 22, 2018 and this information can be used as the basis for the hydraulically calculated design.
    - a. Date: June 22<sup>nd</sup>, 2018
    - b. Time: Unknown
    - c. Performed by: Draper Aden Associates
    - d. Location of Residual Fire Hydrant R: West side of Henry Street approximately 350 feet south of the intersection with Caroline Street.
    - e. Location of Flow Fire Hydrant F: The Northeast Corner of the intersection between Caroline Street and Henry Street.
    - f. Static Pressure at Residual Fire Hydrant R: 65 psi
    - g. Measured Flow at Flow Fire Hydrant F: 1,190 GPM
    - h. Residual Pressure at Residual Fire Hydrant R: 57 psi
  - 2. Sprinkler system design shall be approved by authorities having jurisdiction. Storage hazard classification is based upon preliminary information from the owner. Confirm storage is protected in accordance with NFPA 13.
    - a. Sprinkler Occupancy Hazard Classifications:
      - 1) Electrical Equipment Rooms: Ordinary Hazard, Group 1
      - 2) General Storage Areas: Ordinary Hazard, Group 2
      - 3) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
      - 4) Office and Public Areas: Light Hazard.
  - 3. Minimum Density for Automatic-Sprinkler Piping Design:
    - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft..
    - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft..
    - c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft..
  - 4. Maximum Protection Area per Sprinkler: According to UL listing.
  - 5. Maximum Protection Area per Sprinkler: In accordance with NFPA 13 for each Occupancy Hazard Classification.

## 2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 30, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
- C. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

- D. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- E. Uncoated-Steel Couplings: ASTM A 865, threaded.
- F. Uncoated Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- G. Malleable- or Ductile-Iron Unions: UL 860.
- H. Cast-Iron Flanges: ASME 16.1, Class 125.
- I. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
- J. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
- K. Grooved-Joint, Steel-Pipe Appurtenances:
  - 1. Pressure Rating: 175-psig minimum.
  - 2. Painted Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
  - 3. 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.
- L. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

## 2.3 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating:
  - 1. Standard-Pressure Piping Specialty Valves: 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. Standard: UL 193.
  - 2. Design: For horizontal or vertical installation.
  - 3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
  - 4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
  - 5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
  - 6. 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.

G. Automatic (Ball Drip) Drain Valves:

1. Standard: UL 1726.
2. Pressure Rating: 175-psig minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4.
5. End Connections: Threaded.

H. Fire Department Connection:

1. Fire department connection shall be projecting type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass finish. The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm 2-1/2 inch diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963.

2.4 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175-psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: 175-psig minimum.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

D. Adjustable Drop Nipples:

1. Standard: UL 1474.
2. Pressure Rating: 250-psig minimum.
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.

5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

## 2.5 SPRINKLERS

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- C. 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.
- D. Sprinkler Finishes: Chrome plated.
- E. 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, one piece, flat.
  2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- F. Sprinkler Guards:
  1. Standard: UL 199.
  2. Type: Wire cage with fastening device for attaching to sprinkler.

## 2.6 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Electrically Operated Alarm Bell:
  1. Standard: UL 464.
  2. Type: Vibrating, metal alarm bell.
  3. Size: 6-inch minimum diameter.
  4. Finish: Red-enamel factory finish, suitable for outdoor use.
  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.
- C. Water-Flow Indicators:
  1. Standard: UL 346.
  2. Water-Flow Detector: Electrically supervised.
  3. 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.

4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Design Installation: Horizontal or vertical.

D. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Components: Single-pole, double-throw switch with normally closed contacts.
4. Design: Signals that controlled valve is in other than fully open position.
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.

2.7 PRESSURE GAGES

- A. Standard: UL 393.
- B. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- C. Pressure Gage Range: 0- to 250-psig minimum,
- D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required herein.
- B. Report test results promptly and in writing.

3.2 WATER-SUPPLY CONNECTIONS

- A. Connect sprinkler piping to building's interior water-distribution piping. Start at plumb, level 6" flange within mechanical room.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.3 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. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- I. 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.
- J. Install alarm devices in piping systems.
- K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- M. Fill sprinkler system piping with water.
- N. Install sleeves for piping penetrations of walls, ceilings, and floors.
- O. Install sleeve seals for piping penetrations of concrete walls and slabs.
- P. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- 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 above-ground 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. 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. 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.
- J. 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.

### 3.5 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. Install backflow preventers instead of check valves in potable-water-supply sources.
- 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.

### 3.6 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of tile ceiling panels.

### 3.7 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.

### 3.8 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. 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.

### 3.9 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.

### 3.10 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 threaded ends, cast-iron threaded fittings, and threaded or grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.

- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, 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. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
  - 4. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 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. Standard-weight black-steel pipe with plain ends; steel welding fittings; and welded joints.
  - 4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
  - 5. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.
- E. Standard-pressure, wet-pipe sprinkler system, NPS 5 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. Standard-weight black-steel pipe with plain ends; steel welding fittings; and welded joints.
  - 4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
  - 5. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.

### 3.12 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
  - 1. Rooms without Ceilings: Upright sprinklers.
  - 2. Rooms with Suspended Ceilings: Semi-recessed.
  - 3. Wall Mounting: Sidewall sprinklers.
  - 4. Spaces Subject to Freezing: Pendent, dry sprinklers.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
  - 1. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
  - 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 22 05 13 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 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 NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

#### 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 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

## 2.4 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. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.
  - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. 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 22 05 13

## SECTION 22 05 17 - 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. Sleeve-seal fittings.
  - 3. Grout.

#### 1.3 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

#### 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: 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: Stainless steel.
  - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

- 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: 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.

## 2.4 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, 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 annular clear space between piping and concrete slabs and walls.
  - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
  2. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
  3. Using 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 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 07 92 00 "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 07 84 13 "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 water-tight seal.

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

### 3.4 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: Galvanized-steel wall sleeves.
- 2. Concrete Slabs-on-Grade:
  - a. Piping Smaller Than NPS 6: Galvanized-steel-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.

END OF SECTION 22 05 17

## **SECTION 22 05 18 - ESCUTCHEONS 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. Escutcheons.
  - 2. Floor plates.

#### **1.3 ACTION SUBMITTALS**

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

### **PART 2 - PRODUCTS**

#### **2.1 ESCUTCHEONS**

- A. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- B. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed and exposed-rivet hinge, and spring-clip fasteners.

#### **2.2 FLOOR PLATES**

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass 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 insulated 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 or split-casting brass type with polished, chrome-plated finish.
- c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- d. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
- e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
- g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

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. All new escutcheons shall be straight and tight to wall or floor after installation.

END OF SECTION 22 05 18

## SECTION 22 05 19 - 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. Liquid-in-glass thermometers.
  - 2. Thermowells.
  - 3. Dial-type pressure gages.
  - 4. Gage attachments.
  - 5. Test plugs.
- B. Related Sections:
  - 1. Section 22 11 16 "Domestic Water Piping" for water meters inside the building.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
  - 1. Product Data: Metering devices and components.

#### 1.4 INFORMATIONAL SUBMITTALS

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

#### 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 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. Terrice, H. O. Co.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 6-inch nominal size.
4. Case Form: Back angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.
  - a. Design for Thermowell Installation: Bare stem.
9. Connector: 3/4 inch, with ASME B1.1 screw threads.
10. 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 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, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, 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.

### B. Heat-Transfer Medium: Mixture of graphite and glycerin.

## 2.3 PRESSURE GAGES

### A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ametek U.S. Gauge.
  - b. Ashcroft Inc.
  - c. Ernst Flow Industries.
  - d. Flo Fab Inc.
  - e. Terrice, H. O. Co.

- f. Watts; a Watts Water Technologies company.
- 2. Standard: ASME B40.100.
- 3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
- 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
- 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
- 6. Movement: Mechanical, with link to pressure element and connection to pointer.
- 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
- 8. Pointer: Dark-colored metal.
- 9. Window: plastic.
- 10. Ring: Metal.
- 11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

## 2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

## 2.5 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Flow Design, Inc.
  - 2. Miljoco Corporation.
  - 3. Peterson Equipment Co., Inc.
  - 4. Sisco Manufacturing Company, Inc.
  - 5. Trerice, H. O. Co.
  - 6. Watts; a Watts Water Technologies company.
  - 7. Weiss Instruments, Inc.
  - 8. Weksler Glass Thermometer Corp.
- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

## 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 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 test plugs in piping tees.
- K. Install thermometers in the following locations:
  - 1. Inlet and outlet of each water heater.
- L. 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.
  - 4. Inlet and Outlet of water treatment system.

### 3.2 CONNECTIONS

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

### 3.3 ADJUSTING

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

### 3.4 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.

- B. Scale Range for Domestic Hot-Water Piping: 20 to 240 deg F.

### 3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Water Piping: 0 to 100 psi.

END OF SECTION 22 05 19

## SECTION 22 05 23 - GENERAL-DUTY VALVES 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. Brass ball valves.
  - 2. Bronze ball valves.
  - 3. Iron ball valves.
  - 4. Bronze gate valves.

- B. Related Sections:

- 1. Section 22 05 53 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
  - 2. Section 22 11 13 "Facility Water Distribution Piping" for valves applicable only to this piping.
  - 3. Section 22 11 16 "Domestic Water Piping" for valves applicable only to this piping.

#### 1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. RS: Rising stem.

#### 1.4 ACTION SUBMITTALS

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

#### 1.5 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 2. ASME B31.1 for power piping valves.
  - 3. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 for valve materials for potable-water service.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, grooves, and weld ends.
  - 3. Set angle, gate, and globe valves closed to prevent rattling.
  - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
  - 5. Set butterfly valves closed or slightly open.
  - 6. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand-wheels or stems as lifting or rigging points.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
  - 1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- E. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

F. Valve Bypass and Drain Connections: MSS SP-45.

## 2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Crane Co.; Crane Valve Group; Crane Valves.
  - b. Milwaukee Valve Company.
  - c. NIBCO INC.
2. Description:
  - a. Standard: MSS SP-110.
  - b. SWP Rating: 150 psig.
  - c. CWP Rating: 600 psig.
  - d. Body Design: Two piece.
  - e. Body Material: Forged brass.
  - f. Ends: Threaded.
  - g. Seats: PTFE or TFE.
  - h. Stem: Brass.
  - i. Ball: Chrome-plated brass.
  - j. Port: Full.

## 2.3 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Stainless Steel Ball Valves with Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. American Valve, Inc.
  - b. Conbraco Industries, Inc.; Apollo Valves.
  - c. Crane Co.; Crane Valve Group; Crane Valves.
  - d. Hammond Valve.
  - e. Lance Valves; a division of Advanced Thermal Systems, Inc.
  - f. Legend Valve.
  - g. Milwaukee Valve Company.
  - h. NIBCO INC.
  - i. Red-White Valve Corporation.
  - j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Three piece.
- e. Body Material: Stainless.
- f. Ends: Threaded.
- g. Seats: PTFE or TFE.
- h. Stem: Stainless.
- i. Ball: Stainless.
- j. Port: Full.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

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

#### 3.2 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.

#### 3.3 ADJUSTING

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

#### 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
  - 1. Shutoff Service: Ball.
  - 2. Throttling Service: or ball valves.
- B. If valves with specified SWP classes or CWP ratings are not available, 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 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
  - 2. For Grooved-End Copper Tubing: Valve ends may be grooved.

### 3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
  - 1. Bronze and Brass Valves: May be provided with lead free solder-joint ends instead of threaded ends.
  - 2. Ball Valves: Three piece, full port, stainless steel with stainless steel trim.

END OF SECTION 22 05 23

## SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Brass ball valves.
  - 2. Bronze ball valves.

#### 1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. RPTFE: Reinforced polytetrafluoroethylene.
- C. WOG: Water, oil, gas.

#### 1.3 ACTION SUBMITTALS

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

#### 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, and soldered ends.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

### PART 2 - PRODUCTS

#### 2.1 SOURCE LIMITATIONS

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

## 2.2 PERFORMANCE REQUIREMENTS

- A. Standards:

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

- B. ASME Compliance:

- 1. ASME B1.20.1 for threads for threaded end valves.
- 2. ASME B16.1 for flanges on iron valves.
- 3. ASME B16.5 for flanges on steel valves.
- 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
- 5. ASME B16.18 for cast copper solder-joint connections.
- 6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
- 7. ASME B16.34 for flanged and threaded end connections
- 8. ASME B31.9 for building services piping valves.

- C. Provide bronze valves 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 Actuator Type:

- 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
- 2. Hand Lever: For quarter-turn valves smaller than NPS 4.

- G. Valves in Insulated Piping:

- 1. Provide 2-inch extended neck stems.
- 2. Extended operating handles with nonthermal-conductive covering 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.

## 2.3 BRASS BALL VALVES

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

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

following, or approved equal:

- a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
  - b. Jomar Valve.
  - c. Milwaukee Valve Company.
  - d. Red-White Valve Corp.
2. Standard: MSS SP-110; MSS SP-145.
  3. CWP Rating: 600 psig.
  4. Body Design: Two piece.
  5. Body Material: Forged brass.
  6. Ends: Threaded or soldered.
  7. Seats: PTFE.
  8. Stem: Stainless steel.
  9. Ball: Stainless steel, vented.
  10. Port: Full.

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:
  - a. Viega LLC.
2. Standard: MSS SP-110; MSS SP-145; IAPMO/ANSI Z1157.
3. CWP Rating: Minimum 200 psig.
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Press.
7. Press-End Connections Rating: Minimum 200 psig.
8. Seats: PTFE or RPTFE.
9. Stem: Stainless steel.
10. Ball: Stainless steel, vented.
11. Port: Full.
12. O-Ring Seal: Buna-N or EPDM.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper

size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

- E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

### 3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.
- B. Provide support to piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position to allow full valve actuation movement.
- F. Valve Tags: Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

### 3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

### 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.
- B. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

### 3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 3 and Smaller:

- 1. Brass ball valves, two piece with full port, and stainless steel trim. Provide with solder or

2. press-connection-joint ends.  
Bronze ball valves, two piece with full port, and stainless steel trim. Provide with solder or press-connection-joint ends.

END OF SECTION 220523.12

## SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Bronze, lift check valves.
  - 2. Bronze, swing check valves.
  - 3. Bronze, swing check valves, press ends.

#### 1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer.
- C. NBR: Nitrile butadiene rubber (also known as Buna-N).

#### 1.3 ACTION SUBMITTALS

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

#### 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, grooves, press connections, and weld ends.
  - 3. Set check valves in either closed or open position.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's instructions.

### PART 2 - PRODUCTS

#### 2.1 SOURCE LIMITATIONS

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

## 2.2 PERFORMANCE REQUIREMENTS

- A. Standards:

1. The U.S. Safe Drinking Water Act (SDWA) has required national compliance with less than or equal to 0.25 percent weighted average lead content at wetted surfaces for pipe, fittings, and devices intended to convey or dispense water for human consumption since January 2014. The IPC and the UPC have the same requirements. Items in compliance with NSF 61 and NSF 372 also comply with this requirement. Some manufacturers choose to comply with this requirement through independent testing and have "certified lead-free" products, which may or may not have NSF 61 or NSF 372 certification.
2. Domestic water piping check valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372, or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

- B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges for metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper solder joint.
6. ASME B16.22 for wrought copper solder joint.
7. ASME B16.51 for press joint.
8. ASME B31.9 for building services piping valves.

- C. AWWA Compliance: Comply with AWWA C606 for groove-end connections.

- D. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

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

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

- G. Valve Bypass and Drain Connections: MSS SP-45.

## 2.3 BRONZE, LIFT CHECK VALVES

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

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. Crane Fluid Systems; Crane Co.
- c. Jenkins Valves; a Crane Co. brand.
- d. NIBCO INC.
- e. Stockham; a Crane Co. brand.

2. Description:

- a. Standard: MSS SP-80, Type 1.
- b. CWP Rating: 200 psig.
- c. Body Design: Vertical flow.
- d. Body Material: ASTM B61 or ASTM B62, bronze.
- e. Ends: Threaded or soldered. See valve schedule articles.
- f. Disc: Bronze.

2.4 BRONZE SWING CHECK VALVES

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

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. Crane Fluid Systems; Crane Co.
- c. Jenkins Valves; a Crane Co. brand.
- d. NIBCO INC.
- e. Stockham; a Crane Co. brand.

2. Description:

- a. Standard: MSS SP-80, Type 3.
- b. CWP Rating: 200 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B62, bronze.
- e. Ends: Threaded or soldered. See valve schedule articles.
- f. Disc: Bronze.

B. Bronze, Swing Check Valves, Press Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

- a. NIBCO INC.

2. Description:

- a. Standard: MSS SP-80 and MSS SP-139.
- b. CWP Rating: Minimum 200 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B584, bronze.
- e. Ends: Press.
- f. Press Ends Connection Rating: Minimum 200 psig
- g. Disc: Brass or bronze.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. Install valves so that stems are horizontal or slope upward from centerline of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.
- H. Check Valves: Install check valves for proper direction of flow.
  - 1. Swing Check Valves: In horizontal position with hinge pin level.
  - 2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
  - 3. Lift Check Valves: With stem upright and plumb.
- I. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- J. Adhere to manufacturer's installation instructions. When soldering or brazing valves, do not heat

valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

### 3.3 ADJUSTING

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

### 3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
  - 1. Pump-Discharge Check Valves:
    - a. NPS 2 and Smaller: Bronze, swing check valves with bronze disc.
    - b. NPS 2-1/2 and Larger for Domestic Water: Iron, swing check valves with lever and weight or spring; or iron, center-guided, resilient-seat check valves.
    - c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron, swing check valves with lever and weight or spring.
- 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 and Smaller: Threaded, soldered, or press-end connections.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flange or threaded.

### 3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
  - 1. Bronze, swing check valves with bronze disc, Class 125, with soldered end connections.
  - 2. Bronze, swing check valves with press-end connections.

END OF SECTION 220523.14

## SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

#### 1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- 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.

#### 1.5 ACTION SUBMITTALS

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

## 1.6 INFORMATIONAL SUBMITTALS

- A. Materials.

## PART 2 - PRODUCTS

### 2.1 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 or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
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.

### 2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, 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.

### 2.3 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Buckaroos, Inc.
  2. Carpenter & Paterson, Inc.
  3. Clement Support Services.
  4. ERICO International Corporation.
  5. National Pipe Hanger Corporation.
  6. Pipe Shields Inc.
  7. Piping Technology & Products, Inc.
  8. Rilco Manufacturing Co., Inc.
  9. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig or ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

## 2.4 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.

## 2.5 PIPE POSITIONING SYSTEMS

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

## 2.6 EQUIPMENT SUPPORTS

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

## 2.7 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, 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 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. 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-69 and MSS SP-89. 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 A 36/A 36M, 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 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 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 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 and larger if pipe is installed on rollers.
3. Shield Dimensions for Pipe: Not less than the following:
  - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
  - b. NPS 4: 12 inches long and 0.06 inch thick.
  - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
4. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

### 3.2 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.

### 3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded 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.

### 3.4 ADJUSTING

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

### 3.5 PAINTING

- A. Touchup: 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.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09 91 23 "Interior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

### 3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 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 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.
  - 2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
  - 3. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
  - 4. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 6.
- 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.
  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.
- 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 for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F 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 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.
    - b. Medium (MSS Type 32): 1500 lb.
    - c. Heavy (MSS Type 33): 3000 lb.
  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.
  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-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Comply with MFMA-103 for metal framing system 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 22 05 29

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

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed-restrained-spring isolators.
5. Pipe-riser resilient support.
6. Resilient pipe guides.
7. Elastomeric hangers.
8. Spring hangers.
9. Snubbers.
10. Restraints - rigid type.
11. Restraints - cable type.
12. Restraint accessories.
13. Post-installed concrete anchors.
14. 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 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

#### 1.3 DEFINITIONS

- A. Designated Seismic System: A plumbing component that requires design in accordance with ASCE/SEI 7, Ch. 13 and for which the Component Importance Factor is greater than 1.0.
- B. IBC: International Building Code.
- C. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

#### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-force-restraint component.
4. 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 ICC-ES product listing.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

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.
  - g. Refer to drawing S-001 for wind and seismic load information.
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, 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.
- D. Refer to structural drawings S-001 for wind and seismic load information.

## PART 2 - PRODUCTS (NOT APPLICABLE)

### 2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
  2. Size: Factory or field cut to match requirements of supported equipment.
  3. 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. Infused nonwoven cotton or synthetic fibers.
  6. Load-bearing metal plates adhered to pads.
  7. Sandwich-Core Material: Resilient and elastomeric.
    - a. Surface Pattern: Smooth, ribbed, or waffle pattern.
    - b. Infused nonwoven cotton or synthetic fibers.

### 2.2 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.

## 2.3 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.

## 2.4 HOUSED-RESTRAINED-SPRING ISOLATORS

### A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable non-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.
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.

## 2.5 PIPE-RISER RESILIENT SUPPORT

### A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch Thick Neoprene:

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3447 KPa) on isolation material providing equal isolation in all directions.

## 2.6 RESILIENT PIPE GUIDES

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

## 2.7 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.

## 2.8 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.

## 2.9 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.

## 2.10 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.

## 2.11 RESTRAINTS - CABLE TYPE

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

## 2.12 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.

## 2.13 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. Adhesive Anchor Bolts:

1. 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 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.
- D. 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.

## 2.14 CONCRETE INSERTS

- A. Provide preset concrete inserts, which are seismically prequalified in accordance with ICC-ES AC466 testing.
- B. Comply with ANSI/MSS 58.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation, wind-load control, and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- 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.

### 3.3 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. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- F. 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 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-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.
- 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 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.

### 3.4 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 221116 "Domestic Water Piping" and Section 221119 "Domestic Water Piping Specialties" for piping flexible connections.

### 3.5 ADJUSTING

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

### 3.6 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. 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.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 220548

## SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
  - 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. Brady Corporation.
    - b. Brimar Industries, Inc.
    - c. Carlton Industries, LP.

- d. Champion America.
  - e. Craftmark Pipe Markers.
  - f. emedco.
  - g. Kolbi Pipe Marker Co.
  - h. LEM Products Inc.
  - i. Marking Services, Inc.
  - j. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
  3. Letter Color: Black.
  4. Background Color: White.
  5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
  6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
  7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
  8. Fasteners: Stainless-steel rivets or self-tapping screws.
  9. 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.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

## 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. Carlton Industries, LP.
  4. Champion America.
  5. Craftmark Pipe Markers.
  6. emedco.
  7. LEM Products Inc.
  8. Marking Services Inc.
  9. National Marker Company.
  10. Seton Identification Products.
  11. Stranco, Inc.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: Black.

- D. Background Color: White.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- 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. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
  - 2. Brady Corporation.
  - 3. Brimar Industries, Inc.
  - 4. Carlton Industries, LP.
  - 5. Champion America.
  - 6. Craftmark Pipe Markers.
  - 7. emedco.
  - 8. Kolbi Pipe Marker Co.
  - 9. LEM Products Inc.
  - 10. Marking Services Inc.
  - 11. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to **[partially cover]** **[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 pipe size and an arrow indicating flow direction.
  - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
  - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

## 2.4 STENCILS

A. Stencils for Piping:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Brimar Industries, Inc.
  - b. Carlton Industries, LP.
  - c. Champion America.
  - d. Craftmark Pipe Markers.
  - e. Kolbi Pipe Marker Co.
  - f. Marking Services Inc.
2. Lettering Size: Size letters according to ASME A13.1 for piping.
3. Stencil Material: Aluminum Brass Fiberboard Fiberboard or metal.
4. Stencil Paint: Exterior, gloss, alkyd enamel acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
5. Identification Paint: Exterior, alkyd enamel acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.5 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
  2. Brady Corporation.
  3. Brimar Industries, Inc.
  4. Carlton Industries, LP.
  5. Champion America.
  6. Craftmark Pipe Markers.
  7. emedco.
  8. Kolbi Pipe Marker Co.
  9. LEM Products Inc.
  10. Marking Services Inc.
  11. Seton Identification Products.
- B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  2. Fasteners: Brass wire-link chain or beaded chain or S-hook.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data.

## 2.6 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Brady Corporation.
  - 2. Brimar Industries, Inc.
  - 3. Carlton Industries, LP.
  - 4. Champion America.
  - 5. Craftmark Pipe Markers.
  - 6. emedco.
  - 7. Kolbi Pipe Marker Co.
  - 8. LEM Products Inc.
  - 9. Marking Services Inc.
  - 10. Seton Identification Products.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
  - 1. Size: 3 by 5-1/4 inches minimum.
  - 2. Fasteners: Brass grommet and wire Reinforced grommet and wire or string.
  - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
  - 4. Color: Safety yellow background with black lettering.

## PART 3 - EXECUTION

### 3.1 PREPARATION

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

### 3.2 GENERAL INSTALLATION 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.

### 3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### 3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in Section 09 91 23 "Interior Painting."
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
  - 1. Identification Paint: Use for contrasting background.
  - 2. Stencil Paint: Use for pipe marking.
- 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. Near each valve and control device.
  - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
  - 4. Near major equipment items and other points of origination and termination.
  - 5. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
  - 6. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Pipe Label Color Schedule:
  - 1. Domestic Water Piping
    - a. Background: Safety green.
    - b. Letter Colors: White.
  - 2. Sanitary Waste and Storm Drainage Piping:
    - a. Background Color: Safety black.
    - b. Letter Color: White.

### 3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
  - 1. Valve-Tag Size and Shape:

- a. Cold Water: 1-1/2 inches,.
  - b. Hot Water: 1-1/2 inches,.
- 2. Valve-Tag Colors:
  - a. Cold Water: Safety green.
  - b. Hot Water: Safety green.
- 3. Letter Colors:
  - a. Cold Water: White.
  - b. Hot Water: White.

### 3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 22 05 53

## SECTION 220719 - PLUMBING 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 plumbing piping services:
  - 1. Domestic cold-water piping.
  - 2. Domestic hot-water piping.
  - 3. Domestic recirculating hot-water piping.
  - 4. Storm-water and overflow piping.
  - 5. Roof drains and rainwater leaders.
  - 6. Supplies and drains for handicap-accessible lavatories and sinks.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. Sustainable Design Submittals:
  - 1. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
  - 2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

#### 1.4 INFORMATIONAL SUBMITTALS

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

#### 1.5 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 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.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
  - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

#### 1.7 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.
- C. Coordinate installation and testing of heat tracing.

#### 1.8 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," and "Indoor 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 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Aeroflex USA, Inc.
    - b. Armacell LLC.
    - c. K-Flex USA.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include to the following:
    - a. Johns Manville; a Berkshire Hathaway company.
    - b. Knauf Insulation.
    - c. Manson Insulation Inc.
    - d. Owens Corning.
- H. Mineral-Fiber, Preformed Pipe Insulation:
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Johns Manville; a Berkshire Hathaway company.
    - b. Knauf Insulation.
    - c. Manson Insulation Inc.
    - d. Owens Corning.
  - 2. Type I, 850 Deg F 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 Insulating Cement: Comply with ASTM C 195.

## 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. Adhesives and sealants shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Flexible Elastomeric: Comply with MIL-A-24179A, Type II, Class I.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Aeroflex USA, Inc.
    - b. Armacell LLC.
    - c. Foster Brand; H. B. Fuller Construction Products.
    - d. K-Flex USA.
  - 2. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of 80 g/L or less.
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Childers Brand; H. B. Fuller Construction Products.
    - b. Eagle Bridges - Marathon Industries.
    - c. Foster Brand; H. B. Fuller Construction Products.
    - d. Mon-Eco Industries, Inc.
  - 2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
  - 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. Dow Corning Corporation.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. P.I.C. Plastics, Inc.
    - d. Speedline Corporation.
  - 2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.

## 2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
2. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
  - a. Childers Brand; H. B. Fuller Construction Products.
  - b. Foster Brand; H. B. Fuller Construction Products.
  - c. Knauf Insulation.
  - d. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

## 2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Childers Brand; H. B. Fuller Construction Products.
    - b. Foster Brand; H. B. Fuller Construction Products.
    - c. Vimasco Corporation.
  3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
  4. Service Temperature Range: 0 to plus 180 deg F.
  5. Color: White.

## 2.6 SEALANTS

- A. 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.
  4. Color: White.
  5. Sealant shall have a VOC content of 420 g/L or less.

6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

## 2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
    - a. Johns Manville; a Berkshire Hathaway company.
    - b. P.I.C. Plastics, Inc.
    - c. Proto Corporation.
    - d. Speedline Corporation.
  2. Adhesive: As recommended by jacket material manufacturer.
  3. Color: White.
  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.

## 2.8 TAPES

- A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
  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. Compac Corporation.
    - b. Ideal Tape Co., Inc., an American Biltrite Company.
    - c. Venture Tape.
  2. Width: 2 inches.
  3. Thickness: 6 mils.
  4. Adhesion: 64 ounces force/inch in width.
  5. Elongation: 500 percent.
  6. Tensile Strength: 18 lbf/inch in width.

## 2.9 SECUREMENTS

- A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
  2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- C. Wire: 0.080-inch nickel-copper alloy or 0.062-inch soft-annealed, stainless steel.

## 2.10 PROTECTIVE SHIELDING GUARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
1. Engineered Brass Company.
  2. Insul-Tect Products Co.
  3. McGuire Manufacturing.
  4. Truebro.
  5. Zurn Industries, LLC.
- B. Protective Shielding Pipe Covers,:
1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- C. Protective Shielding Piping Enclosures:
1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  - 1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and 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-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches 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 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. Cleanouts.

### 3.4 PENETRATIONS

- A. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations 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.

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: 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.
- E. Insulation Installation at Floor Penetrations:
  1. Pipe: Install insulation continuously through floor penetrations.
  2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

### 3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- 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 over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
  5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.
- 3.6 INSTALLATION OF 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.

3.7 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 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, 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.

### 3.8 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 overlap at seams and joints.
  2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
  3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
  1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

### 3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
  1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

### 3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
  1. Inspect 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.

- D. All insulation applications will be considered defective Work if sample inspection reveals non-compliance with requirements.

### 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. Underground piping.
  - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

### 3.12 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
  - 1. All pipe sizes: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- B. Domestic Hot and Recirculated Hot Water:
  - 1. All pipe sizes: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- C. Stormwater and Overflow (Horizontal Only):
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Roof Drain and Overflow Drain Bodies:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 1 inch thick.
- E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 1/2 inch 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. PVC: 20 mils thick.
- D. Piping, Exposed:
  - 1. PVC: 20 mils thick.

END OF SECTION 220719

## SECTION 22 11 16 - DOMESTIC WATER 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. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
  - 2. Encasement for piping.
- B. Related Requirements:
  - 1. Section 22 11 13 "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.
- B. Sustainable Design Submittals:
  - 1. Product Data: For adhesives, indicating VOC content.
  - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

#### 1.4 INFORMATIONAL SUBMITTALS

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

### 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 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

## 2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B88, Type k, ASTM B 88, Type L and ASTM B 88, Type M water tube, drawn temper.
- B. Cast-Copper, Lead Free Solder-Joint Fittings: ASME B16.18, pressure fittings.
- C. Wrought-Copper, Lead Free Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- E. Copper Unions:
  - 1. MSS SP-123.
  - 2. Cast-copper-alloy, hexagonal-stock body.
  - 3. Ball-and-socket, metal-to-metal seating surfaces.
  - 4. Solder-joint or threaded ends.

## 2.3 PIPING JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys.
- B. Flux: ASTM B 813, water flushable.
- C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- D. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

## 2.4 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. Sleeve-Type Transition Coupling: AWWA C219.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Cascade Waterworks Mfg. Co.
- b. Dresser, Inc.
- c. Ford Meter Box Company, Inc. (The).
- d. Jay R. Smith Mfg. Co.
- e. JCM Industries, Inc.
- f. Romac Industries, Inc.
- g. Smith-Blair, Inc.
- h. Viking Johnson.

## 2.5 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating non-conductive 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 Industrial Unions, LLC.
    - e. Jomar Valve.
    - f. Matco-Norca.
    - g. Watts; a Watts Water Technologies company.
    - h. Wilkins.
    - i. Zurn Industries, LLC.
  - 2. Standard: ASSE 1079.
  - 3. Pressure Rating: 125 psig minimum at 180 deg F.
  - 4. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company.
    - b. Central Plastics Company.
    - c. Matco-Norca.
    - d. Watts; a Watts Water Technologies company.
    - e. Wilkins.
    - f. Zurn Industries, LLC.
  - 2. Standard: ASSE 1079.
  - 3. Factory-fabricated, bolted, companion-flange assembly.
  - 4. Pressure Rating: 125 psig minimum at 180 deg F.
  - 5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

- A. Comply with requirements in Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

### 3.2 PIPING INSTALLATION

- 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 generally as indicated unless deviations to layout are approved on coordination drawings.
- B. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 05 19 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 22 11 19 "Domestic Water Piping Specialties."
- C. Install shutoff valve immediately upstream of each dielectric fitting.
- D. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 11 19 "Domestic Water Piping Specialties."
- E. Install domestic water piping level and plumb.
- F. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- G. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- I. 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.
- J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- K. Install piping to permit valve servicing.
- L. 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.
- M. Install piping free of sags and bends.
- N. Install fittings for changes in direction and branch connections.

- O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- P. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- Q. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23 "Domestic Water Pumps."
- R. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

### 3.3 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. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

### 3.4 TRANSITION FITTING INSTALLATION

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

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

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

### 3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

### 3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.

2. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.

2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.

3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.

4. NPS 2-1/2: 108 inches with 1/2-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

### 3.7 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. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
  - 2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
  - 3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

### 3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.

### 3.9 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 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.

### 3.10 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. 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.
  - 4. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
  - 5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
  - 6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
  - 7. Check plumbing specialties and verify proper settings, adjustments, and operation.

### 3.11 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 of chlorine. Isolate with valves and allow to stand for 24 hours.
      - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

- c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
  - d. Repeat procedures if biological examination shows contamination.
  - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Clean non-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 procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
    - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

### 3.12 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
  - 1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and brazed soldered joints.
- E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be:
  - 1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed soldered joints.
- F. Below grade domestic water piping NPS 2" to 4" shall be:
  - 1. Hard copper tube, ASTM B88, Type K.

### 3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
3. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION 22 11 16

## SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

1. Vacuum breakers.
2. Strainers.
3. Hose bibbs.
4. Wall hydrants.
5. Drain valves.
6. Water-hammer arresters.
7. Trap-seal primer valves.
8. Trap-seal primer systems.
9. Washing machine wall box.
10. Ice maker outlet box.

- B. Related Requirements:

1. Section 22 05 19 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 22 11 16 "Domestic Water Piping" for water meters.
3. Section 22 32 00 "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Section 22 47 13 "Drinking Fountains" for water filters for water coolers.
5. Section 22 47 16 "Pressure Water Coolers" for water filters for water coolers.
6. Section 22 47 23 "Remote Water Coolers" for water filters for water coolers.

#### 1.3 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.
- C. Sustainable Design Submittals:
  1. Product Data: For water consumption.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

## 1.5 CLOSEOUT SUBMITTALS

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

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14. Mark "NSF-pw" on plastic piping components.

### 2.2 PERFORMANCE REQUIREMENTS

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

### 2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ames Co.
  - b. Ames Fire & Waterworks.
  - c. Apollo Valves; Conbraco Industries, Inc.
  - d. Cash Acme.
  - e. FEBCO.
  - f. Rain Bird Corporation.
  - g. Toro Company (The).
  - h. Watts; a Watts Water Technologies company.
  - i. Zurn Industries, LLC.
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze.

- B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Apollo Valves; Conbraco Industries, Inc.

- b. Arrowhead Brass Products.
  - c. Cash Acme.
  - d. Legend Valve & Fitting, Inc.
  - e. MIFAB, Inc.
  - f. Prier Products, Inc.
  - g. Watts; a Watts Water Technologies company.
  - h. Woodford Manufacturing Company.
  - i. Zurn Industries, LLC.
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Chrome or nickel plated.

## 2.4 TEMPERATURE-ACTUATED, WATER MIXING VALVES

### A. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Acorn Engineering Company.
  - b. Apollo Valves; Conbraco Industries, Inc.
  - c. Armstrong International, Inc.
  - d. Lawler Manufacturing Company, Inc.
  - e. Leonard Valve Company.
  - f. Powers.
  - g. Symmons Industries, Inc.
  - h. Zurn Industries, LLC.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 120 F.
9. Tempered-Water Design Flow Rate: 20 gpm.
10. Selected Valve Flow Rate at 45-psig Pressure Drop: **<Insert gpm>**.
11. Pressure Drop at Design Flow Rate: 5 psig.
12. Valve Finish: Rough bronze.
13. Piping Finish: Copper.
14. Cabinet: Factory fabricated, stainless steel, for recessed surface mounting and with hinged, stainless-steel door.

## 2.5 HOSE BIBBS

### A. Hose Bibbs (HB):

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.

3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.

## 2.6 WALL HYDRANTS

### A. Nonfreeze Wall Hydrants (WH):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. Josam Company.
  - c. MIFAB, Inc.
  - d. Prier Products, Inc.
  - e. Tyler Pipe; a subsidiary of McWane Inc.
  - f. Watts; a Watts Water Technologies company.
  - g. Woodford Manufacturing Company.
  - h. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for exposed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
9. Nozzle and Wall-Plate Finish: Polished nickel bronze.
10. Operating Keys(s): Two with each wall hydrant.

## 2.7 DRAIN VALVES

### A. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

## 2.8 WATER-HAMMER ARRESTERS

### A. Water-Hammer Arresters WHA:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. AMTROL, Inc.
  - b. Jay R. Smith Mfg. Co.
  - c. Josam Company.
  - d. MIFAB, Inc.
  - e. Precision Plumbing Products.
  - f. Sioux Chief Manufacturing Company, Inc.
  - g. Tyler Pipe; a subsidiary of McWane Inc.
  - h. Watts; a Watts Water Technologies company.
  - i. Zurn Industries, LLC.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

## 2.9 TRAP-SEAL PRIMER DEVICE

### A. Supply-Type, Trap-Seal Primer Device (Lavatory CW Supply or Flush Valve Type):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. MIFAB, Inc.
  - c. Precision Plumbing Products. (Basis of Design)
  - d. Sioux Chief Manufacturing Company, Inc.
  - e. Watts; a Watts Water Technologies company.
  - f. Zurn Industries, LLC.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

## 2.10 WASHING MACHINE WALL BOX (P-10)

- A. Provide Guy Grey Model Stainless Steel "WMOB" model with quarter turn valves box material 304 S.S., 20-gauge, Qtr. valves with 1/2" MIP/Sweat connections furnished 2" slipknot drain.

## 2.11 ICE MAKER OUTLET BOX

- A. Provide IPS Water-Tite Plastic square ice maker outlet box with lead free quarter turn hammer valve or equal..

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- B. Install balancing valves in locations where they can easily be adjusted.
- C. Install water-hammer arresters in water piping according to PDI-WH 201.
- D. 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 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
  - 1. Calibrated balancing valves.
  - 2. Primary, thermostatic, water mixing valves.
  - 3. Primary water tempering valves.
  - 4. Supply-type, trap-seal primer valves.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

#### 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

#### 3.4 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.

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

END OF SECTION 22 11 19

## SECTION 221123.21 - INLINE, DOMESTIC-WATER 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. Horizontally mounted, in-line, close-coupled centrifugal pumps.
  - 2. Vertically mounted, in-line, close-coupled centrifugal pumps.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members to which pumps will be attached.
  - 2. Size and location of initial access modules for acoustical tile.
- B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

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

## 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 instructions for handling.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- D. Seismic Performance: Inline, domestic-water 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."
  - 2. Component Importance Factor: 1.5.

### 2.2 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.
- B. Capacities and Characteristics:
  - 1. Capacity: 10 gpm.
  - 2. Total Dynamic Head: 25 feet.
  - 3. Pump Control: Pressure switch.
  - 4. Pump Speed: 1750 rpm.
  - 5. Motor Horsepower: 0.5 value.
  - 6. Electrical Characteristics:
    - a. Volts: 120 V.
    - b. Phases: Single phase.
    - c. Hertz: 60 Hz.

C. Pump Construction:

1. Casing:

- a. Radially split cast iron with threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
- b. Built to permit servicing of pump internals without disturbing the casing or the suction and discharge piping.
- c. Gauge port tapings at suction and discharge nozzles.

2. Impeller: Cast Bronze, statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve Carbon: Steel shaft meeting AISI C1045 with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
4. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
5. Seal: Mechanical, with Manufacturers standard flushed mechanical seal..
6. Bearings: Grease-lubricated or permanently lubricated ball type.
7. Minimum Working Pressure: 175 psig.
8. Continuous Operating Temperature: 225 deg F.

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

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

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

B. Capacities and Characteristics:

1. Capacity: 10t gpm.
2. Total Dynamic Head: 25 feet.
3. Casing Material: Cast iron.
4. Impeller Material: ASTM B584, cast bronze.
5. Minimum Operating Pressure: 175 psig.
6. Maximum Continuous Operating Temperature: 225 deg F.
7. Pump Control: Pressure switch.
8. Pump Speed: 1750.
9. Motor Horsepower: 0.5.
10. Electrical Characteristics:
  - a. Volts: 120 V.
  - b. Phases: Single phase.
  - c. Hertz: 60 Hz.

C. Pump Construction:

1. Casing: Radially split bronze, with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections.
2. Impeller: Cast Bronze, statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve: Steel or stainless-steel shaft, with copper-alloy shaft sleeve.

4. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
5. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Bearings: Oil-lubricated; bronze-journal or ball type.
7. Minimum Working Pressure: 175 psig.
8. Continuous Operating Temperature: 225 deg F.

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

## 2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing 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.

## 2.5 CONTROLS

- A. Pressure Switches: Electric, adjustable for control of water-supply pump.

1. Type: Water-immersion pressure sensor, for installation in piping.
2. Operation of Pump: On or off.
3. Transformer: Provide if required.
4. Power Requirement: 120 V ac .
5. Settings: Start pump at **<Insert pressure>** and stop pump at **<Insert pressure>**.

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

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 50 to 125 deg F 100 to 240 deg F.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 120 V ac.
6. Settings: Start pump at 105 deg F and stop pump at 125 deg F.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.

- C. Pump Mounting:
  - 1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.
  - 1. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- E. Install pressure switches in water-supply piping.
- F. Install thermostats in hot-water return piping.

### 3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
  - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
    - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
    - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
    - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
    - d. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:
  - 1. Section 220523.12 "Ball Valves for Plumbing Piping."
  - 2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
  - 3. Section 220523.14 "Check Valves for Plumbing Piping."
  - 4. Section 220523.15 "Gate Valves for Plumbing Piping."
  - 5. Install pressure gauge[ **and snubber**] at suction of each pump and pressure gauge[ **and snubber**] at discharge of each pump. Install at integral pressure-gauge tapings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."

### 3.4 CONTROL CONNECTIONS

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

### 3.5 IDENTIFICATION

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

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections per manufacturer's installation and start-up procedures.
- E. Tests and Inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

### 3.7 STARTUP SERVICE

- A. Perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping.
  - 4. Set pressure switches, and thermostats, for automatic starting and stopping operation of pumps.
  - 5. Perform the following startup checks for each pump before starting:

- a. Verify bearing lubrication.
  - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
  - c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
  7. Start motor.
  8. Open discharge valve slowly.
  9. Adjust temperature settings on thermostats.
  10. Adjust timer settings.

### 3.8 ADJUSTING

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

END OF SECTION 221123.21

## SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Pipe, tube, and fittings.
  - 2. Specialty pipe fittings.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
  - 1. Product Data: For adhesives, indicating VOC content.
  - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For waste and vent piping, 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. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.

### 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. Soil, Waste, and Vent Piping: 10-foot head of water.

- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

## 2.2 PIPING MATERIALS

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. 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 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

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

## 2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. CISPI, Hubless-Piping Couplings:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ANACO-Husky.
    - b. Charlotte Pipe and Foundry Company.
    - c. Dallas Specialty & Mfg. Co.
    - d. Fernco Inc.
    - e. Josam Company.
    - f. Matco-Norca.
    - g. MIFAB, Inc.
    - h. Mission Rubber Company, LLC; a division of MCP Industries.
    - i. NewAge Casting.
    - j. Stant.
    - k. Tyler Pipe; a subsidiary of McWane Inc.
  - 2. Standards: ASTM C 1277 and CISPI 310.
  - 3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. ANACO-Husky.
  - b. Charlotte Pipe and Foundry Company.
  - c. Clamp-All Corp.
  - d. Dallas Specialty & Mfg. Co.
  - e. MIFAB, Inc.
  - f. Mission Rubber Company, LLC; a division of MCP Industries.
  - g. NewAge Casting.
  - h. Stant.
  - i. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Charlotte Pipe and Foundry Company.
  - b. MG Piping Products Company.
2. Standard: ASTM C 1277.
3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.5 PVC PIPE AND FITTINGS

- A. Comply with NSF 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.
- B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- C. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
- D. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- E. Adhesive Primer: ASTM F 656.
  1. Adhesive primer shall have a VOC content of 550 g/L or less.
  2. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. Solvent Cement: ASTM D 2564.
  1. Solvent cement shall have a VOC content of 510 g/L or less.

## 2.6 SPECIALTY PIPE FITTINGS

### A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Nonpressure Transition Couplings:
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Dallas Specialty & Mfg. Co.
    - 2) Fernco Inc.
    - 3) Froet Industries LLC.
    - 4) Mission Rubber Company, LLC; a division of MCP Industries.
    - 5) Plastic Oddities.
  - b. Standard: ASTM C 1173.
  - c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
  - d. End Connections: Same size as and compatible with pipes to be joined.
  - e. Sleeve Materials:
    - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
    - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
    - 3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
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, LLC; a division of MCP Industries.
  - 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.
  - d. End Connections: Same size as and compatible with pipes to be joined.

## PART 3 - EXECUTION

### 3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 20 00 "Earth Moving."

### 3.2 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 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. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
  - 1. 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.
  - 2. 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.
    - a. Straight tees, elbows, and crosses may be used on vent lines.
  - 3. Do not change direction of flow more than 90 degrees.
  - 4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
    - a. Reducing size of waste piping in direction of flow is prohibited.
- L. Lay buried building waste 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.
- M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
  2. Above Ground Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
  3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- O. Install aboveground PVC piping according to ASTM D 2665.
- P. Install engineered soil and waste and vent piping systems as follows:
1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
  2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
  3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
- Q. Plumbing Specialties:
1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
    - a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
    - b. Comply with requirements for cleanouts specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
  2. Install drains in sanitary waste gravity-flow piping.
    - a. Comply with requirements for drains specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
- R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

### 3.3 JOINT CONSTRUCTION

- A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- C. Plastic, Nonpressure-Piping, Solvent-Cement 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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

### 3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
  1. Install transition couplings at joints of piping with small differences in ODs.
  2. In Waste Drainage Piping: Unshielded, nonpressure transition couplings.

### 3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."
  1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
  2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
  3. Vertical Piping: MSS Type 8 or Type 42, clamps.
  4. Install individual, straight, horizontal piping runs:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
  5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  6. Base of Vertical Piping: MSS Type 52, spring hangers.

- C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
  - 2. NPS 3: 60 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
  - 4. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/4: 72 inches with 3/8-inch rod.
  - 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
  - 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
  - 4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
  - 5. NPS 6: 10 feet with 5/8-inch rod.
  - 6. NPS 8: 10 feet with 3/4-inch rod.
- I. Install supports for vertical copper tubing every 10 feet.
- J. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
  - 2. NPS 3: 48 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
- K. Install supports for vertical PVC piping every 48 inches.
- L. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

### 3.6 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 waste and vent piping to the following:
  - 1. Plumbing Fixtures: Connect waste 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 waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

### 3.7 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.
- B. Comply with requirements for identification specified in Section 22 05 53 "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 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 waste 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.
    - 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 waste and vent piping until it has been tested and approved.
    - a. Expose work that was covered or concealed before it was tested.
  3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
    - a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
    - b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    - c. 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.
  - a. 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.
  - b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
  - c. Air pressure must remain constant without introducing additional air throughout period of inspection.
  - d. 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.

### 3.9 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping 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 PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
- E. Repair damage to adjacent materials caused by waste and vent piping installation.

### 3.10 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
  1. Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
  1. Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
- D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
  1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
  2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
- E. Underground, soil and waste piping NPS 5 and larger shall be any of the following:
  1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
  2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; coupled joints.

END OF SECTION 22 13 16

## SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

1. Cleanouts.
2. Through-penetration firestop assemblies.
3. Miscellaneous sanitary drainage piping specialties.

- B. Related Requirements:

1. Section 22 14 23 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

#### 1.3 DEFINITIONS

- A. PVC: Polyvinyl chloride.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

### PART 2 - PRODUCTS

#### 2.1 ASSEMBLY DESCRIPTIONS

- A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary waste piping specialty components.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

#### 2.2 CLEANOUTS

- A. Cast-Iron Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. Josam Company.
  - c. MIFAB, Inc.
  - d. Tyler Pipe; a subsidiary of McWane Inc.
  - e. Watts; a Watts Water Technologies company.
  - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk Countersunk or raised-head Raised-head, brass cast-iron plastic plug, square top.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts (CO):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. Josam Company.
  - c. Oatey.
  - d. Sioux Chief Manufacturing Company, Inc.
  - e. Tyler Pipe; a subsidiary of McWane Inc.
  - f. Watts; a Watts Water Technologies company.
  - g. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M for adjustable housing cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch, except 6" pipe may be 4".
4. Type: Adjustable housing Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Spigot.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. Josam Company.
  - c. MIFAB, Inc.
  - d. Tyler Pipe; a subsidiary of McWane Inc.

- e. Watts; a Watts Water Technologies company.
- f. Zurn Industries, LLC.
- 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 Plug:
  - a. Brass.
  - b. Countersunk.
  - c. Drilled and threaded for cover attachment screw.
  - d. Size: Same as or not more than one size smaller than cleanout size.
- 6. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

## 2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

### A. Open Drains:

- 1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets.
- 2. Size: Same as connected waste piping.

### B. Floor-Drain, Trap-Seal Primer Fittings (All Floor Drains To Be Equipped):

- 1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
- 2. Size: Same as floor drain outlet with NPS 1/2 side inlet.
- 3. All floor drains shall have square top.

### C. 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.

### D. Frost-Resistant Vent Terminals:

- 1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
- 2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

### E. Expansion Joints:

- 1. Standard: ASME A112.6.4.
- 2. Body: Cast iron with bronze sleeve, packing, and gland.
- 3. End Connections: Matching connected piping.
- 4. Size: Same as connected soil, waste, or vent piping.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

#### A. Equipment Mounting:

1. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
2. Comply with requirements for vibration-isolation devices specified in Section 22 05 48.13 "Vibration Controls for Plumbing Piping and Equipment."

#### B. 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.

#### C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

#### D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

#### E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

#### F. Install fixture air-admittance valves on fixture drain piping.

#### G. Install stack air-admittance valves at top of stack vent and vent stack piping.

#### H. Install air-admittance-valve wall boxes recessed in wall.

#### I. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 07 62 00 "Sheet Metal Flashing and Trim."

#### J. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 07 62 00 "Sheet Metal Flashing and Trim."

#### K. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

1. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

#### L. Assemble open drain fittings and install with top of hub 1 inch above floor.

#### M. Install deep-seal traps on floor drains and other waste outlets, if indicated.

- N. 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.
- O. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- P. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- Q. Install vent caps on each vent pipe passing through roof.
- R. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- S. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- T. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- U. Install wood-blocking reinforcement for wall-mounting-type specialties.
- V. 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 22 13 16 "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. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

### 3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
  - 1. Nameplates and signs are specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

### 3.4 FIELD QUALITY CONTROL

#### A. Tests and Inspections:

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

### 3.5 PROTECTION

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

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain FOG disposal systems. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION 22 13 19

## SECTION 221413 - FACILITY STORM DRAINAGE PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Hubless, cast-iron soil pipe and fittings.
  - 2. PVC pipe and fittings.
  - 3. Specialty pipe and fittings.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Shop Drawings: For **[controlled-flow]** **[siphonic]** roof drainage system. Include calculations, plans, and details.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail storm drainage piping. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members to which drainage piping will be attached or suspended from.
- B. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

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

#### 1.6 FIELD CONDITIONS

- A. Interruption of Existing Storm Drainage 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 Construction Manager and Owner no fewer than two days in advance of proposed interruption of storm drainage service.
2. Do not proceed with interruption of storm drainage service without Construction Manager and Owner's written permission.

## 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.
  2. Storm Drainage, Force-Main Piping: 100 psig.

### 2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings:
1. Marked with CISPI collective trademark and NSF certification mark.
  2. Standard: ASTM A 888 or CISPI 301.
- B. CISPI, Hubless-Piping Couplings:
1. Couplings shall bear CISPI collective trademark[ **and NSF certification mark**].
  2. Standards: ASTM C 1277 and CISPI 310.
  3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- C. Cast-Iron, Hubless-Piping Couplings:
1. Standard: ASTM C 1277.
  2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

### 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. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
- D. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- E. Adhesive Primer: ASTM F 656.

- F. 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 Cast-Iron Soil Pipes: ASTM C 564, rubber.
    - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
    - 3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
4. Shielded, 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.
5. Pressure Transition Couplings:
  - a. Standard: AWWA C219.
  - b. Description: Metal, sleeve-type couplings same size as pipes to be joined, and with pressure rating at least equal to and ends compatible with pipes to be joined.
  - c. Center-Sleeve Material: Manufacturer's standard.
  - d. Gasket Material: Natural or synthetic rubber.
  - e. Metal Component Finish: Corrosion-resistant coating or material.

## PART 3 - EXECUTION

### 3.1 INSULATION

- A. Contractor shall insulate all horizontal storm water mains.

### 3.2 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. 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. 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 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
  - 2. Horizontal Storm Drainage Piping: 2 percent downward in direction of flow.
- L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
  - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- M. Install steel piping according to applicable plumbing code.
- N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- O. Install aboveground ABS piping according to ASTM D 2661.

- P. Install aboveground PVC piping according to ASTM D 2665.
- Q. Install underground ABS and PVC piping according to ASTM D 2321.
- R. 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.
    - a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
    - b. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
  - 2. Install drains in storm drainage gravity-flow piping.
    - a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."
- S. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors.
  - 1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs.
  - 1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors.
  - 1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

### 3.3 JOINT CONSTRUCTION

- A. Hubless, Cast-Iron Soil Piping Coupled Joints:
  - 1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.
  - 1. Cut threads full and clean using sharp dies.
  - 2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
    - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

- b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
  - c. Do not use pipe sections that have cracked or open welds.
- C. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- D. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- E. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
- F. Plastic, 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.
- G. Joint Restraints and Sway Bracing:
  - 1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
    - a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
    - b. Provide rigid sway bracing for pipe and fittings 4 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.
    - c. Provide rigid sway bracing for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction and branch openings.

### 3.4 SPECIALTY PIPE FITTING INSTALLATION

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

### 3.5 HANGER AND SUPPORT INSTALLATION

- 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 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. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 5. Install individual, straight, horizontal piping runs:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
  - 6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 7. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
  - 2. NPS 3: 60 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
  - 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
  - 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
  - 6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/4: 84 inches with 3/8-inch rod.
  - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
  - 3. NPS 2: 10 feet with 3/8-inch rod.
  - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
  - 5. NPS 3: 12 feet with 1/2-inch rod.
  - 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
- I. Install supports for vertical steel piping every 15 feet.
- J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

- K. Install supports for vertical copper tubing every 10 feet.
- L. Install hangers for **PVC** piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 3: 48 inches with 1/2-inch rod.
  - 2. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
- M. Install supports for vertical **PVC** piping every 48 inches.
- N. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

### 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.
  - 2. Install horizontal backwater valves.
  - 3. Comply with requirements for backwater valves cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."
- D. Connect force-main piping to the following:
  - 1. Storm Sewer: To exterior force main.
  - 2. Sump Pumps: To sump pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance.
- F. Make connections according to the following unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

### 3.7 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. 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. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
    - a. Expose work that was covered or concealed before it was tested.
  - 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.
    - a. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
  - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 4. Prepare reports for tests and required corrective action.
- D. Piping will be considered defective if it does not pass tests and inspections.

- E. 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. Aboveground storm drainage piping **NPS 6and smaller** shall be any of the following:
  - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
  - 2. Hubless, cast-iron soil pipe and fittings; CISPI, hubless-piping couplings; and coupled joints.
  - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
  - 4. Dissimilar Pipe-Material Couplings: Shielded nonpressure transition couplings.
- C. Underground storm drainage piping NPS 6and smaller shall be any of the following:
  - 1. **Service** class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
  - 2. Hubless, cast-iron soil pipe and fittings; CISPI, cast-iron, hubless-piping couplings; and coupled joints.
  - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
  - 4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221413

## SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Metal roof drains.
- B. Related Requirements:
  - 1. Section 076200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
  - 2. Section 078413 "Penetration Firestopping" for firestopping roof penetrations.

#### 1.3 ACTION SUBMITTALS

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

#### 1.4 QUALITY ASSURANCE

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

### PART 2 - PRODUCTS

#### 2.1 METAL ROOF DRAINS

- A. Cast-Iron, Small-Sump, General-Purpose Roof Drains RD/OD-X:
  - 1. Standard: ASME A112.6.4.
  - 2. Body Material: Cast iron.
  - 3. Dimension of Body: Nominal 8-inch diameter.
  - 4. Combination Flashing Ring and Gravel Stop: Required.
  - 5. Outlet: Bottom.
  - 6. Outlet Type: No hub.
  - 7. Extension Collars: As required
  - 8. Underdeck Clamp: As required.
  - 9. Dome Material: Cast iron.
  - 10. Wire Mesh: Stainless steel or brass over dome.
  - 11. Vandal-Proof Dome: Required.

12. Provide watts RD-250 or equal with 3" pipe size.

### 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.
  1. Comply with requirements in Section 078413 "Penetration Firestopping."

#### 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.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

#### 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 22 32 00 - DOMESTIC WATER FILTRATION EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Freestanding cartridge filters.
- B. Related Sections:
  - 1. Section 22 11 19 "Domestic Water Piping Specialties" for plumbing piping strainers.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: freestanding cartridge filters, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - 1. The term "withstand" means that "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."

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for filters capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For water filtration equipment. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Wiring Diagrams: For power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For freestanding cartridge filters, 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. Certificates of Shop Inspections and Data Reports: For products required to have ASME label, signed by product manufacturer.
- C. Welding certificates.
- D. Source quality-control reports.
- E. Field quality-control reports.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For water filtration equipment to include in emergency, operation, and maintenance manuals.
- 1.7 MATERIALS MAINTENANCE 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. Cartridge-Filter Elements: Elements for cartridge filters equal to 400 percent of amount installed for each size and media indicated.
- 1.8 QUALITY ASSURANCE
- A. Source Limitations: Obtain each type of water filtration equipment through one source from a single manufacturer.
- B. Welding Qualifications: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code.
- 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 NSF 61 Annex, "Drinking Water System Components - Health Effects," for all components that will be in contact with potable water.
- 1.9 PROJECT CONDITIONS
- A. Feedwater Analysis: To Be Determined.
- B. Feedwater Properties:

1. Inlet Water Pressure: 15 psig.
2. Water Temperature: 50 Deg F.

#### 1.10 COORDINATION

- A. Coordinate size and location of concrete bases with actual equipment provided.

### PART 2 - PRODUCTS

#### 2.1 CARTRIDGE FILTERS

- A. Freestanding Cartridge Filters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Campbell Manufacturing, Inc.
  - b. Cycron Corporation.
  - c. Diamond Water Conditioning; a Griesbach company.
  - d. Diamond Water Systems, Inc.
  - e. Eden Equipment Company.
  - f. Filter Specialists, Inc.
  - g. Filterspun.
  - h. Filtrine Manufacturing Company.
  - i. General Electric Company; GE Water & Process Technologies.
  - j. Graver Technologies.
  - k. Harmsco, Inc.
  - l. Hydro Systems International.
  - m. ITT Water Equipment Technologies.
  - n. Keystone Filter Division.
  - o. Krystal Klear Filtration.
  - p. Parker Hannifin Corp.
  - q. PEP Filters, Inc.
  - r. Rosedale Products, Inc.
  - s. Serfilco, Ltd.
  - t. Shelco Filters.
  - u. Watts; a Watts Water Technologies company.
2. Description: Simplex, floor-mounted housing with replaceable element(s) for removing suspended particles from water.
  - a. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through water filter element(s); with element support(s) and base, feet, or skirt.
    - 1) Fabricate supports and base, feet, or skirt and attachment to housing with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
    - 2) Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.

- 3) Steel Tank Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if housing is stainless steel.
    - 4) Plastic Housing Pipe Connections NPS 2-1/2 and Larger: 150-psig plastic flanges.
  - b. Element(s): Replaceable; of shape to fit housing.
3. Capacity and Characteristics:
  - a. Filtrate Design Concentrations:
    - 1) The water test evaluation, produced after the well(s) are drilled, will detail the need for chemical filtration/treatment.

General Filter Design:

- 2) Continuous Flow: 14-18 gpm.
    - 3) Peak Flow: N.A.
    - 4) Filtration Efficiency: 98 percent retention of suspended particles 10 micrometers and larger from feedwater of listed filtrate design concentrations.
    - 5) Pressure Drop: Not to exceed 2 psig at filter design flow rate when clean.
  - b. Housing:
    - 1) Material: Plastic.
    - 2) Pressure Rating: 125 psig.
    - 3) Seals: NBR.
    - 4) Diameter: TBD.
    - 5) Height or Length: TBD.
    - 6) Inlet and Outlet Size: 1 1/4".
    - 7) Drain Size: Not applicable.
  - c. Elements:
    - 1) Number Required: Two in parallel at 100% each.
    - 2) Media: Pleated polyester.

## 2.2 SOURCE QUALITY CONTROL

- A. Before shipping, hydrostatically test carbon filters, circulating sand filters, multimedia sand filters, greensand filters, and separators to minimum of one and one-half times pressure rating.
- B. Prepare test reports.

## 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 filters.

- B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls and floors for suitable conditions where filters will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 EQUIPMENT MOUNTING

- A. Equipment Mounting: Install filters on concrete bases. Comply with requirements for concrete bases specified in Section 03 30 00 "Cast-in-Place Concrete."
  - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around 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.

### 3.3 CARTRIDGE-FILTER INSTALLATION

- A. Install cartridge filters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Equipment Mounting: Install freestanding cartridge filters on concrete base. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."
  - 1. Exception: Omit concrete bases if installation directly on floor is indicated.
- C. Attach wall brackets for off-floor, wall-mounted, cartridge filter to vertical surface. Attach housing(s), and base if any, to wall bracket.
- D. Install housings for off-floor, in-line, cartridge filters in piping.
- E. Install filter elements in cartridges.
- F. Install seismic restraints for freestanding cartridge-filter housings and anchor to building structure.

### 3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

- C. Make piping connections between water filtration equipment and dissimilar-metal water piping with dielectric fittings. Comply with requirements for dielectric fittings specified in Section 22 11 16 "Domestic Water Piping."
- D. Install shutoff valves on feedwater-inlet and filtrate-outlet piping of each water filtration equipment filter and on inlet and outlet headers.
  - 1. Comply with requirements for metal general-duty valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
  - 2. Comply with requirements for plastic valves specified in Section 22 11 16 "Domestic Water Piping."
  - 3. Exception: Water filtration equipment with factory-installed shutoff valves at locations indicated.
- E. Install pressure gages on feedwater-inlet and filtrate-outlet piping of each water filtration equipment filter. Comply with requirements for pressure gages specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
  - 1. Exception: Water filtration equipment with factory-installed pressure gages at locations indicated.
  - 2. Exception: Cartridge water filters.
- F. Install valved bypass water piping around each water filtration equipment filter and separator.
  - 1. Comply with requirements for metal general-duty valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," Section 22 05 23.14 "Check Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
  - 2. Comply with requirements for plastic valves specified in Section 22 11 16 "Domestic Water Piping."
  - 3. Comply with requirements for water piping specified in Section 22 11 16 "Domestic Water Piping."
  - 4. Exception: Bag-type water filtration equipment.
  - 5. Exception: Cartridge water filtration equipment.
- G. Install drains as indirect wastes to spill into open drains or over floor drains.

### 3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

### 3.6 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. 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 unit operation.
  3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Domestic water filtration equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 22 32 00

## SECTION 22 33 00 – ELECTRIC DOMESTIC-WATER HEATERS

### 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. Commercial, electric, storage, domestic-water heaters.
  - 2. Domestic-water heater accessories.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Commercial domestic-water heaters 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."

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
  - 1. Product Data: For energy efficiency.
- C. Shop Drawings:
  - 1. Wiring Diagrams: For power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of commercial, electric, domestic-water heater, from manufacturer.
  - 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. Warranty: Sample of special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

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

#### 1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IES 90.1 - 2010.
  1. Comply with efficiency requirements in ASHRAE 189.1, which supersede requirements in ASHRAE/IESNA 90.1.
- C. ASME Compliance: ASME-code construction, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section IV, Part HLW.
- D. MFR: Shall have certification to the ISO Quality Management System.
- E. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."
- F. UL1453 "Electric Booster and Electrical Storage Water Heaters for portable Water".

#### 1.8 COORDINATION

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

#### 1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
    - a. Structural failures including storage tank and supports.
    - b. Faulty operation of controls.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
  2. Warranty Periods: From date of Substantial Completion.
    - a. Commercial, Electric, Storage, Domestic-Water Heaters:
      - 1) Storage Tank: Twenty- Five years. (15 yrs. Full, 10 yrs., non-prorated)
      - 2) Controls and Other Components: Five years.
    - b. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
      - 1) Storage Tank: Three Five.
      - 2) Controls and Other Components: Two years.'
    - c. Solar Domestic Water Heating System:
      - 1) Storage Tank: Twenty- Five years. (15 yrs. Full, 10 yrs., non-prorated)
      - 2) Controls and Other Components: Five years.

## PART 2 - PRODUCTS

### 2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

- A. Commercial, Electric, Storage, Domestic-Water Heaters:
1. Main Building – MFR. Hubbel; Model SE80-0-SLT4 or equal.
  2. Standard: UL 1453.
  3. Storage-Tank Construction: ASME-code, steel vertical arrangement.
    - a. The storage section of the water heater shall be ASME HLW stamped and National Board Registered for a maximum allowable working pressure of 150 psi and pressure tested at 1-1/2 times working pressure.
    - b. All tank connections/ fittings shall be nonferrous. Tank shall be equipped with a ball-type drain valve. Tank design will include a manway sized access to the tank interior.
    - c. The storage tank shall be an unlined pressure vessel constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923 Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2 and ASTM G123 – 00(2005) "Standard Test Method for Evaluating Stress-

Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution.”

- d. Waterside surfaces shall be welded internally utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.
- e. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product.
- f. Materials shall meet ASME Section II Material requirements and be accepted by NST 61 for municipal potable water systems. Storage tank materials shall contain more than 80% post-consumer recycled materials and be 100% recyclable.
- g. Water contacting tank surfaces will be non-porous and exhibit 0% water absorption.
- h. Lined or plated storage tanks will not be acceptable.
- i. Water heaters that require anodes will not be acceptable.
- j. Heating elements will be as indicated on DWG schedules.
- k. Heating elements will be sheathed in Incoloy. Each element will individually mount to the tank by means of a four-bolt bronze flange over stainless steel studs with an o-ring seal. A fused magnetic contactor will be supplied for each power circuit. Maximum current per circuit will be 50 amps on the three-phase units.

4. Factory-installed Storage-Tank Appurtenances:

- a. As a minimum, the heater will be equipped with the following:
  - 1) Electronic low water cutoff
  - 2) An immersion operating thermostat
  - 3) Immersion temperature limiting device
  - 4) An ASME rated temperature and pressure relief valve
  - 5) And options as selected on form PV 8130
- b. Operating and safety controls shall meet the requirements of UL. Operating and safety controls shall meet the requirements MASS code
- c. The water heater shall employ an electronic operating control with digital temperature readout. Operator shall be capable of connecting to a building automation system through serial connection using Modbus RTU protocol.
- d. A protocol gateway for BacNet MSTP/IP will be provided

5. Factory-Installed Storage-Tank Appurtenances:

- a. Anode Rod: Replacement magnesium.
- b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
- c. Drain Valve: ASSE 1005.
- d. Insulation: Comply with ASHRAE/IESNA 90.1.
- e. Jacket: Steel with enameled finish.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

- A. Domestic-Water Expansion Tanks:
  - 1. AMTROL Thermax-Trol; ST Series
    - a. Main Building; Model ST-12
  - 2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air pre-charge to minimum system-operating pressure at tank.
  - 3. Construction:
    - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
    - b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
    - c. Air-Charging Valve: Factory installed.
  - 4. Capacity and Characteristics:
    - a. Working-Pressure Rating: 150 psig.
    - b. Capacity Acceptable: 4 gal. minimum.
    - c. Air Precharge Pressure: 40 psi (field adjustable).
- B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.
- C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.
- D. Heat-Trap Fittings: ASHRAE 90.2.
- E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and calibrated balancing valves to provide balanced flow through each domestic-water heater.
  - 1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
  - 2. Comply with requirements for balancing valves specified in Section 22 11 19 "Domestic Water Piping Specialties."
- F. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig-maximum outlet pressure unless otherwise indicated.
- G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
- H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

- I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- K. Domestic-Water Heater and Solar Water Storage Tanks 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 above the floor.
- L. Domestic-Water Heater and Solar Water Storage Tanks Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

### 2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect domestic-water heaters and Solar Water Storage Tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters and Solar Water Storage Tanks to minimum of one and one-half times pressure rating before shipment.
- C. Electric, domestic-water heaters and Solar Water Storage Tanks will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and re-inspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.
- 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 03 30 00 "Cast-in-Place Concrete."
  - 1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters and Solar Water Storage Tanks if installation on stand, bracket, suspended platform, or directly on floor is indicated.
  - 2. Maintain manufacturer's recommended clearances.
  - 3. Arrange units so controls and devices that require servicing are accessible.
  - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - 8. Anchor domestic-water heaters to substrate.

- B. Install electric, domestic-water heaters and Solar Water Storage Tanks level and plumb, according to 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 22 05 23.12 "Ball Valves for Plumbing Piping," Section 22 05 23.13 "Butterfly Valves for Plumbing Piping," and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
- C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-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.
- D. Install water-heater and Solar Water Storage Tanks 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 22 11 19 "Domestic Water Piping Specialties."
- E. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- F. Install thermometers on inlet and outlet piping of residential, solar, electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- G. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- H. Fill electric, domestic-water heaters with water.
- I. Charge domestic-water compression tanks with air.

### 3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

### 3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

### 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.
  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 operation.
  4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Electric, domestic-water heaters and solar water heating system will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and reinspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

### 3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters, and solar domestic water heating system.

END OF SECTION 22 33 00

## SECTION 22 41 00 - RESIDENTIAL PLUMBING FIXTURES

### 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. Kitchen sinks.
  - 2. Breakroom sinks.

#### 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 lavatories.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
  - 1. Same as other fixtures
- C. Shop Drawings: Include diagrams for power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.
- B. Sample Warranty: For special warranty.

### PART 2 - PRODUCTS

#### 2.1 HAND SINKS

- 1. Hand Sinks P-5A: .
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Elkay model LRAD222265, ADA Compliant.
  - b. American Standard.
  - c. Koehler.
- 3. Fixture:
  - a. Shape: square, drop in.
  - b. Nominal Size: 21 by 21 inches.
  - c. Height: 6.5 inches.
  - d. Color Stainless Steel.
  - e. Drain: Grid with NPS 3 outlet.
- 4. Mounting: Drop in
- 5. Faucet: Elkay Model LK6000, pull out spray, chrome plated, 1.5 GPM.

## 2.2 SINK FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

- B. Sink Faucets: Solid brass, kitchen sink.

- 1. General-Duty, Solid-Brass Faucets:
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) P-5A Elkay model LK500, pull out spray, chrome plated, 1.5 GPM.
- 2. Standard: ASME A112.18.1/CSA B125.1.
- 3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
- 4. Finish: Polished chrome plate.
- 5. Maximum Flow Rate: 1.5 unless otherwise indicated.
- 6. Mixing Valve: Single control.
- 7. Backflow-Prevention Device for Hand Spray: Not required.
- 8. Centers: Single hole.
- 9. Mounting: Deck, exposed.
- 10. Handle(s): Lever.
- 11. Spout Type: Swing, shaped tube.
- 12. Spout Outlet: Retracting Sprayer with hose.
- 13. Provide ASSE 1070 mixing valve on all sinks.

## 2.3 DISHWASHER AIR-GAP FITTINGS

- A. Dishwasher Air-Gap Fittings:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. B & K Industries, Inc.

- b. BrassCraft Manufacturing Co.; a Masco company.
  - c. BrassTech Inc.
  - d. Dearborn Brass.
  - e. Geberit US.
  - f. Sioux Chief Manufacturing Company, Inc.
  - g. Watts; a Watts Water Technologies company.
- 2. Standard: ASSE 1021.
- 3. Description: Device designed to prevent backflow of contaminated liquid into domestic dishwashers.
- 4. Material: Plastic body with chrome-plated-brass cover.
- 5. Hose Connections: 5/8-inch-ID inlet and 7/8-inch-ID outlet.
- 6. Capacity: At least 5 gpm; at inlet pressure of at least 5 psig and at temperature of at least 140 deg F.
- 7. Mounting: Deck.
- 8. Hoses: Rubber and suitable for temperature of at least 140 deg F.
  - a. Inlet Hose: 5/8 inch ID and 48 inches long.
  - b. Outlet Hose: 7/8 inch ID and 48 inches long.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

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

#### 3.2 INSTALLATION

- A. Install plumbing fixtures level and plumb according to roughing-in drawings.
- B. Install counter-mounting fixtures in and attached to casework.
- C. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
  - 1. Exception: Use ball or gate valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
- D. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- E. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes unless otherwise indicated.

- F. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck. Connect inlet hose to dishwasher and outlet hose to disposer.
- 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 22 05 18 "Escutcheons for Plumbing Piping."
- H. Seal joints between plumbing fixtures, 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 07 92 00 "Joint Sealants."

### 3.3 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 22 11 16 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

### 3.4 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

### 3.5 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.
- B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 41 00

## SECTION 22 42 13.13 - COMMERCIAL WATER CLOSETS

### 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. Water closets.
- 2. Toilet seats.

#### 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 water closets.
- 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. LEED Submittals:

- 1. Product Data for Prerequisite WE 1 and Credit WE 2: Documentation indicating flow and water consumption requirements.

- C. Shop Drawings: Include diagrams for power, signal, and control wiring.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.

### PART 2 - PRODUCTS

## 2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

### A. Water Closets P-1A: Floor mounted, bottom outlet, top spud.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. American Standard Madera ADA (P-1A)
2. Bowl:
  - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
  - b. Material: Vitreous china.
  - c. Type: Siphon jet.
  - d. Style: Floor mounted bottom outlet, dual flush.
  - e. Height: P-1A Handicapped.
  - f. Rim Contour: Elongated.
  - g. Water Consumption: 1.6 GPF.
  - h. Spud Size and Location: NPS 1-1/2; top.
  - i. Color: White.
3. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.
4. Dual flush pressure assist.
5. Toilet Seat: Solid-plastic open-front.
6. Floor mounted toilet.
7. Flush Valve" Sloan WES 11

## 2.2 TOILET SEATS

### A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. American standard # 5901.100 (P-1A)

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.

B. Install toilet seats on water closets.

C. 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.
3. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

D. 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. Comply with sealant requirements specified in Section 07 92 00 "Joint Sealants."

3.3 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 22 11 16 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 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.

3.5 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 22 42 13.13

## SECTION 22 42 16.13 - COMMERCIAL LAVATORIES

### 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. Lavatories.
- 2. Faucets.

#### 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 lavatories.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
  - 1. Product Data for Prerequisite WE 1 and Credit WE 2: Documentation indicating flow and water consumption requirements.
- C. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.
  - 1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. Servicing and adjustments of automatic faucets.

## 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.

## PART 2 - PRODUCTS

### 1.1 VITREOUS-CHINA WALL MOUNTED LAVATORIES

- A. Lavatory P-3A: Wall mounted.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Kohler Co
    - b. Zurn
    - c. American Standard (Basis of design)
  - 2. Fixture:
    - a. Wall Mounted: American standard Lucerne 0355.12
  - 3. Support: ASME A112.6.1M, Type II, concealed-arm lavatory carrier with escutcheons.
- B. Lavatory Faucets For P-3A: Manual-type, two-handle mixing, general-duty, solid-brass valve.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Zurn Model Sierra Faucet 17440-XL.
  - 2. Standard: ASME A112.18.1/CSA B125.1.
  - 3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
  - 4. Body Type: 4"Centerset.
  - 5. Body Material: Commercial, solid brass.
  - 6. Finish: Polished chrome plate.
  - 7. Maximum Flow Rate: 0.5 gpm.
  - 8. Mounting Type: Deck, exposed.
  - 9. Valve Handle(s): Two lever.
  - 10. Spout: Rigid type.
  - 11. Spout Outlet: Aerator.
  - 12. Drain: Grid Type.

- C. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.

## 2.1 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," 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: Loose key.
- F. Risers:
  - 1. NPS 3/8.
  - 2. Chrome-plated, soft-copper flexible tube riser.

## 2.2 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.
- C. Trap:
  - 1. Size: NPS 1-1/2 by NPS 1-1/4.
  - 2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.
  - 3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 INSTALLATION

- A. Install lavatories level and plumb according to roughing-in drawings.

- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. 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 22 05 18 "Escutcheons for Plumbing Piping."
- E. 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 07 92 00 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

### 3.3 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 22 11 16 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

### 3.4 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

### 3.5 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 22 42 16.13

## SECTION 22 42 16.16 - COMMERCIAL SINKS

### 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 basins.
  - 2. Sink faucets.
  - 3. Supply fittings.
  - 4. Waste fittings.
- B. Related Requirements:
  - 1. Section 22 41 00 "Residential Plumbing Fixtures" for residential sinks.

#### 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 sinks.
  - 2. Include rated capacities, operating characteristics and furnished specialties and accessories.
- B. LEED Submittals:
  - 1. Product Data for Prerequisite WE 1, and Credit WE 2: Documentation indicating flow and water consumption requirements.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

#### 1.5 CLOSEOUT SUBMITTALS

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

#### 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.

## PART 2 - PRODUCTS

### 2.1 SERVICE BASINS

- A. Service Basins P-6: Enameled cast iron, floor mounted.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Acorn Engineering Company.
    - b. Crane Plumbing, L.L.C.
    - c. Florestone Products Co., Inc.
    - d. Stern-Williams Co., Inc.
    - e. Zurn.
  - 2. Fixture:
    - a. Standard: IAPMO PS 99.
    - b. Shape: Corner.
    - c. Nominal Size: 28 by 28 inches.
    - d. Height: 8 inches.
    - e. Tiling Flange: Not required.
    - f. Rim Guard: On front top surfaces.
    - g. Color: Not applicable.
    - h. Drain: Grid with NPS 3 outlet.
  - 3. Mounting: On floor and flush to wall.
  - 4. Faucet: See "Sink Faucets" Article.

### 2.2 SINK FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.
- B. Sink Faucets For: Manual type, two-lever-handle mixing valve.
  - 1. Commercial, Solid-Brass Faucets.
    - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      - 1) Kohler Co.
      - 2) Zurn Z843MI, 8" Sink Faucet.

## 2.3 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.
- C. Trap:
  - 1. Size: NPS 1-1/2.
  - 2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.
  - 3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

## 2.4 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, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

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

### 3.2 INSTALLATION

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Set floor-mounted sinks in leveling bed of cement grout.
- C. 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 22 05 18 "Escutcheons for Plumbing Piping."

- D. 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 07 92 00 "Joint Sealants."
- E. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

### 3.3 CONNECTIONS

- A. Connect sinks 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 22 11 16 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

### 3.4 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

### 3.5 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 22 42 16.16

## SECTION 22 42 23 - COMMERCIAL SHOWERS

### 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. Individual shower receptors.
  - 2. Shower faucets.
  - 3. Grout.
  - 4. Shower Drain.

#### 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 showers.
  - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For shower faucets 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
  - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

### PART 2 - PRODUCTS

#### 2.1 INDIVIDUAL SHOWER UNITS (P-4A)

A. Individual Wall-Mounted Shower Systems:

1. Manufacturers: Subject to compliance with requirements, provide the following:
  - a. American Standard Shower System Kit: Model 1662.600 (P-4A)
  - b. Bradley Corporation: model WS-IWCA-**ADA** (P-4A).
2. Description: Stainless-steel, wall-mounted, surface-enclosure shower fixture with individual nozzles.
3. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
4. Metal Nominal Thickness: 18 gauge.
5. Number of Shower Nozzles: One.
6. Height to Nozzles: Adjustable.
7. Control: Pressure-balance valve with individual hot- and cold-water mixing-valve operation.
8. Control: Thermostatic valve with individual, tempered-water supply and push-button operation.
9. Flow-Control Fitting: 1.5 gpm for each shower head.
10. EPA WaterSense: Required.
11. Soap Dish: Required for each shower head.
12. Mounting: Wall bracket.
13. Supplies: NPS 3/4 copper tubing with valves.

2.2 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, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.3 SHOWER DRAIN

- A. Architectural Tile shower unit option - Provide Zurn model 2415S-DP body assembly with "Type S" strainer and deck plate, 2" pipe size, no hub, stainless steel, clamp collar, material - stainless steel.
- B. Architectu

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Coordinate roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before shower installation.

- B. Examine walls and floors for suitable conditions where showers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Assemble shower components according to manufacturers' written instructions.
- B. Install showers level and plumb according to roughing-in drawings.
- C. Install water-supply piping with stop on each supply to each shower faucet.
  - 1. Exception: Use ball or gate valves if supply stops are not specified with shower. Comply with valve requirements specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
  - 2. Install stops in locations where they can be easily reached for operation.
- 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. Comply with escutcheons requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
- F. Seal joints between showers and 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 07 92 00 "Joint Sealants."

### 3.3 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 22 11 16 "Domestic Water Piping."
- C. Comply with traps and soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

### 3.4 ADJUSTING

- A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

### 3.5 CLEANING AND PROTECTION

- A. After completing installation of showers and basins, inspect and repair damaged finishes.

- B. Clean showers and basins, faucets, 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 and basins for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 42 23

## SECTION 22 47 13 - DRINKING FOUNTAINS

### 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 drinking fountains and related components.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of drinking fountain.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Include operating characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
  - 1. Submit flow rates in accordance with WE-3 requirements.

#### 1.4 CLOSEOUT SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 DRINKING FOUNTAINS

- A. Drinking Fountains: Stainless steel, wall mounted.
  - 1. Stainless-Steel Drinking Fountains:
    - a. P-7, P-7A Elkay: EZWS-ERPBM28K
  - 2. Standards:
    - a. Comply with ASME A112.19.3/CSA B45.4.
    - b. Comply with NSF 61 Annex G.
  - 3. Receptor Shape: integral.
  - 4. Bubblers: Two, with adjustable stream regulator, located on deck.

5. Control: Push bar.
6. Drain: Grid type with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 chrome-plated brass P-trap and waste.
9. Support: Refer to a manufacturers installation instructions.
10. Drinking Fountain Mounting Height: Handicapped/elderly according to ICC A117.1.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

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

#### 3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Set pedestal drinking fountains on floor.
- C. Install recessed drinking fountains secured to wood blocking in wall construction.
- D. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- E. Install water-supply piping with shutoff valve on supply to each fixture 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. Valves are specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
- F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 05 18 "Escutcheons for Plumbing Piping."
- H. 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 07 92 00 "Joint Sealants."

#### 3.3 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 22 11 16 "Domestic Water Piping."
- C. Install ball or gate shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 22 05 23.12 "Ball Valves for Plumbing Piping" and Section 22 05 23.15 "Gate Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.

3.5 CLEANING

- A. After installing fixtures, 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 22 47 13

## SECTION 23 00 00 - MECHANICAL GENERAL REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 REFERENCE TO DIVISION 1

- A. This Section is intended to add to or modify the conditions and requirements given under Division 1. Unaltered conditions and requirements under Division 1 shall remain in effect.
- B. Division 1 and this Section apply to all Work described under Division 23.

#### 1.2 DESCRIPTION OF WORK

- A. The Work includes all construction shown and specified. Construction is mechanical with supporting services of general, electrical, and special trades.
- B. Unless specifically dimensioned, the Work shown on the drawings is diagrammatic, only to show general arrangement.
- C. Include in the Work, all accessories, and appurtenances, necessary and integral, for the intended operation of any system, component or device, as such systems, components and devices are specified.
- D. The fire protection drawings and specifications do not describe and show all the requirements of NFPA and the governing fire code.
- E. Comply with all code and regulatory requirements, whether or not shown or specified.
- F. Flow, control and riser diagrams are part of the Contract Documents.
- G. All power wiring to the terminals of the motors specified under Divisions 25 and 23, including disconnects at motors if necessary and/or required by code, will be provided under Division 26. All interlock wiring and control wiring will be provided under Division 25, except as otherwise specified in other sections of the specifications or indicated on the drawings. Coordinate with Division 25 to determine the exact quantities, sizes and locations of all pipe-mounted, duct mounted and mechanical equipment mounted instrumentation devices that are to be installed under Division 23.
- H. No pipe or conduit shall be allowed to pass through ductwork.
- I. Coordinate installation of mechanical work with other trades and conditions in the building and with the outside site work. Any variance from work specified or shown will be subject to approval by the owner/EOR. Where interferences occur and mechanical work is directed by the owner/ EOR to be relocated, provide such relocation at no additional cost to the owner.
- J. Asbestos or asbestos-containing materials shall not be utilized or allowed on this project. The Contractor shall be rigorous in assuring that all materials, equipment, systems and components thereof do not contain asbestos. Any deviations from this exclusion shall be remedied at the Contractor's expense without regard to prior submittal approvals.

- K. Coordinate with Division 9 for exact locations of ceiling access panels for mechanical equipment and instrumentation. Location of access panels shall be such that the equipment instrumentation devices are easily accessible for servicing.
- L. Coordinate the locations of all floor drains, plumbing and fixtures, outlets, equipment and specialties with the Architectural Contract Drawings.
- M. If the pipe or duct size shown on the drawings does not match with the connection size of the equipment that it is connected to, provide the necessary transition piece.
- N. Installation, Startup and system testing shall be done in strict accordance with manufacturers' written instruction, approved submittals and applicable code and standards.
- O. Drainage operations of any equipment must not damage any building components.
- P. Do not begin any work until time schedules and manner of operations have been approved by the owner. Prior to starting work, the contractor shall visit the site and become familiar with the work area.
- Q. Where existing equipment shall remain in service during construction, provide rerouting and reconnection of mechanical services as required to maintain continuous service.
- R. Protect existing to remain equipment from possible damage during demolition work. Damage will be responsibility of demolition contractor.
- S. It is intended that the building remain protected from damage due to freezing temperatures, existing utilities used for heating shall remain in service until scheduling permits shut down.
- T. It is responsibility of the Contractor to meet all OSHA and work area safety standards and insure that all Subcontractors, visitors etc. comply with those standards.
- U. Execute periodic and final cleaning to keep the work site free from accumulations of waste materials and rubbish, resulting from construction operations. Provide on-site trash collection and removal, to a legal offsite disposal area.
- V. Remove from site existing materials and equipment not intended for reuse in the work and dispose of properly. Review all equipment with the owner prior to disposal.
- W. All permits shall be obtained through Bertie County and any other authorities having jurisdiction.

### 1.3 SUBMITTALS

- A. Shop Drawings, Product Data and Samples - Submit to the owner for review and approval in accordance with the requirements of Division 1 and specific additional instructions within this Section and other Sections in Division 23.
- B. When required, submit shop drawings and product catalog cuts of equipment to governmental authorities having jurisdiction.
- C. Coordination drawings: Submit drawing(s), drawn to scale, to the owner for review and approval indicating installation of:

1. HVAC Floor Plans
2. Mechanical Piping Systems
3. Sanitary and Draining Piping
4. Sprinkler Piping

- D. In order to facilitate the review of submittals, identify proposed products with the identical markings, symbols and nomenclature used in the Contract Documents. Show room names and numbers on all plans.
- E. See Section 09 51 00 for written approvals when this work penetrates acoustical ceilings.
- F. Project Record Documents - Submit in accordance with Section 01 33 23.
- G. Manufacturers Operation, Maintenance and Installation Manuals - Submit in accordance with Section 01 78 23.
- H. Warranties, Bonds, and Service and Maintenance Contracts - Submit in accordance with Section 01 78 23.
- I. Submittal Register - See Section 01 33 00 for a tabulation of all submittals required under Division 23.
- J. Calibration Manuals - Submit in accordance with Division 1.

#### 1.4 CONNECTIONS AND SHUTDOWNS TO EXISTING WORK

- A. Whenever connections and/or shutdowns to existing facilities are required, coordinate with the owner and schedule the work to avoid interruption of services during normal working hours. No work or shutdowns shall start until written authorization of the owner.
- B. Work and connections requiring interruption of services shall be done during unoccupied periods only and with the prior written approval of the owner.

#### 1.5 IDENTIFICATION

- A. Refer to this section and Section 23 21 16, for identification of mechanical equipment and piping systems.

#### 1.6 EQUIPMENT BY OTHERS

- A. Division 1, together with other Sections in the Project Manual, describe equipment that will be furnished by the owner and from other sources.
- B. The setting in place and the protection of this equipment shall be as specified in the appropriate Sections of the specifications.
- C. Provide roughing-in for and make final clearance for moving equipment to final location.
- D. Provide coordination to assure clearance for moving equipment to final location.

- E. Provide testing and balancing for this equipment.
- F. Provide coordination of foundations and structural support of this equipment, and identify any revisions required to Contract Drawings.
- G. Provide painting and identification for this equipment.
- H. Provide accessories, fastenings, fittings and mechanical service for this equipment as shown and as necessary for the installation and proper operation of the equipment.

#### 1.7 MOVING OF EQUIPMENT

- A. Verify that all equipment, including equipment furnished by the owner and from other sources, will pass through final available openings. When equipment or sections of equipment are larger than these openings, install this equipment prior to construction of walls, floors or roofs. If equipment is to be relocated and walls, floors, and roofs already exist written authorization is required by the owner before any existing structure, walls, floors, and roofs are modified.
- B. Use planking or cribbing as required to protect adjoining construction from damage. Protect equipment from damage until construction is completed.
- C. The contract documents may include limitations on dimensions for accessibility to equipment spaces. These dimensions are intended only as a guide. Final requirements are the responsibility of the Prime Contractor.

#### 1.8 CUTTING AND PATCHING

- A. Provide cutting and patching for mechanical work as specified under Section 01 73 29. Coordinate and show locations and sizes for all penetrations of ductwork and piping through walls, floors, partitions and roof. Repair damaged fireproofing and waterproofing to original or better condition.
- B. Do not cut walls, floors, reinforced concrete or structural steel without the owner's permission. Install services without affecting reinforcing steel.

#### 1.9 MANUFACTURERS' SERVICES

- A. The sections of the specifications define which manufacturers' services (i.e., Start-Up, Field Testing, Training, etc.) are required for the various systems and equipment.
- B. Details, time frames and durations of each service, as required, are included in these sections.

#### 1.10 SERVICE AND MAINTENANCE

- A. The sections of the specifications define which equipment and systems require contracted service and maintenance after the date of acceptance by the owner.
- B. At the end of the specified contract period, service/maintenance organizations shall offer renewal of service and maintenance contracts to the owner.

1.11 COMPLIANCE WITH CODES, STANDARDS AND REGULATIONS

- A. Comply with Division 1.

1.12 SUBSTITUTIONS

- A. Specific equipment manufacturers and their model numbers are cited in this Division to establish the desired performance and quality for that equipment.
- B. Products by other manufacturers are acceptable if they comply with all features of that Section and that this compliance can be documented through independent testing. All substitutions shall be approved by the owner/EOR.
- C. If independent test results are unavailable, independent test results may be required by the owner at no cost to the owner.
- D. All substitutions to material and equipment shall be submitted in accordance with the requirements of Section 01 33 29.
- E. Any engineering work required due to substituted equipment, all re-engineering work shall be the responsibility of the contractor at no additional cost to the owner.

1.13 CONCRETE WORK

- A. Cast-in-place concrete for mechanical work will be as specified under Division 3.

1.14 ELECTRICAL WORK

- A. Work and materials required for electrical service, field wiring and connections for mechanical equipment will be as specified under Division 26.
- B. Provide electrical wiring diagrams and information as furnished by the equipment manufacturer.
- C. All electrical components of mechanical equipment, including control panels, shall be UL approved.

1.15 ACCESS SPACE

- A. Space has been allocated for maintenance and removal requirements. The Contractor shall not install ductwork, piping or equipment that will reduce the space allocation below that shown on the contract documents.

1.16 PAINTING

- A. All supplemental steel, supports and hangers required for the installation of Division 23 work shall be prime painted by the Division 23 Contractor when installed. Surface preparation, material and application shall be in accordance with Section 09 91 00, Painting and Finishing.

Finish coat of paint shall also be as specified in Section 09 91 00. Prime painting is only required on carbon steel surfaces. Welds of galvanized surfaces shall be painted with cold galvanizing compound.

#### 1.17 IDENTIFICATION, VALVE TAGS AND CHARTS

- A. All control devices, i.e., panels, switches, starters, pushbutton stations, relays, temperature controls, etc., shall be clearly identified as to their function and the equipment controlled. All equipment such as pumps, fans, heaters, etc., shall be marked to clearly identify equipment and space or duty they serve. Mechanical equipment shall be identified using engraved laminated black and white phenolic legend plates. Letters shall be minimum  $\frac{3}{4}$  inch high white on surrounding black. Plates shall be mounted by means of sheet metal screws. Submit nameplate list for approval. Refer to Section 23 21 16, Mechanical Piping and Accessories and Fittings General Requirements of Mechanical Equipment and Piping Systems.
- B. Piping shall be identified with colored, pre-rolled, semirigid plastic labels as manufactured by Seton or approved equal. Labels shall be Seton "Set mark" system and shall be set around pipes with a field installed high strength cement compound applied along their longitudinal edge. Labels shall be placed around the piping or insulation every 20 feet and with one (1) label on each pipe in rooms smaller than 100sf. A label shall be placed at every major valve and at least 6 feet from exit or entrance to an item of equipment. At Contractor's option, piping concealed above suspended ceilings only, may be identified by stenciling with black paint and taped color bands in accordance with the coding system herein specified.
- C. Labels shall have minimum  $\frac{3}{4}$  inch high black letters for pipes 1 inch and larger, and  $\frac{1}{2}$  inch letters for smaller pipes. All labels shall have flow arrows. Color coding and stencil designations shall be as indicated in pipe material schedule.
- D. All valves except as specified below, shall be provided with 14 gage brass valve tags with stamped-in numbers. Tags shall be secured to valve wheels with a metal chain. Stop valves on individual fixtures or equipment where their function is obvious, or where the fixture of equipment is immediately adjacent, need not be so equipped. Care shall be exercised in scheduling and selecting valve numbers to be indicated on a drawing. Drawing shall show locations, details of arrangements, identity, and function of all service and control valves. One (1) copy of each drawing and schedule shall be mounted under glass where directed. A copy of each drawing and schedule shall also be included as a part of the operations and maintenance manuals. Valve tags shall be Seton or approved equal minimum 1.5 inch round tags with white characters describing system and valve designation.
- E. All ductwork shall have labels with 1-inch-high black letters and directional flow arrows every 20 feet. Label backgrounds shall follow SMACNA-standard HVAC duct identification colors, including green for supply air and blue for general exhaust.

#### 1.18 FACTORY BALANCING OF ROTATING EQUIPMENT

- A. All rotating equipment shall be balanced at the factory to meet the maximum allowable vibration criteria specified in Table 46 of Chapter 48 ("Noise and Vibration Control") in the HVAC Applications Volume of the ASHRAE Handbook.

#### 1.19 MACHINE GUARDING REQUIREMENTS FOR THE INSULATION OF POWER-TRANSMISSION EQUIPMENT

- A. The installation of new Power-Transmission Equipment and its safeguards shall comply with the requirements of 29 CFR 1910 Subpart O – Machinery and Machine Guarding and ANSI B11.19-2010 – Performance Criteria for Safeguards. Equipment and safeguards shall be designed to prevent personnel from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. Equipment and safeguards must meet these minimum general requirements:
1. Prevent contact: The safeguard must prevent hands, arms, and any other part of a worker's body from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or another worker placing parts of their bodies near hazardous moving parts. Comply with the opening distances identified in ANSI B11.19.
  2. Secure: Workers should not be able to easily remove or tamper with the safeguard. Guards and safety devices should be made of durable material that will withstand the conditions of normal use. They must firmly be secured to the machine.
  3. Protect from falling objects: The safeguard should ensure that no objects can fall into moving parts.
  4. Create no new hazards: A safeguard defeats its own purpose if it creates a hazard of its own such as a shear point, a jagged edge, or an unfinished surface which can cause a laceration. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.
  5. Create no interference: Any safeguard which impedes a worker from performing the job quickly and comfortably might soon be overridden or disregarded.
  6. Allow safe lubrication: If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the operator or maintenance worker to enter the hazardous area.
  7. Removal of guards: A main power disconnect switch capable of being locked only in the off position shall be provided to allow for removal of the guard only after lockout tagout operations.

## PART 2 - PRODUCTS

### 2.1 MOTORS

- A. Provide motors of a size adequate to drive the equipment, but in no case less than the size shown or specified. If a motor larger than that specified is required, the Contractor shall bear the expense of changes in foundations, supports, wire and conduit connections, circuit protective devices, or other affected elements of the system. Each motor shall have sufficient capacity to start and operate the machine it drives without exceeding the motor nameplate rating at the speed specified or at the load which may be obtained by the drive provided. Rate motor for continuous duty at 115 percent of rated capacity; base temperature rise on an ambient temperature of one-hundred four (104) degrees Fahrenheit. Provide Aegis shaft grounding brushes for all motors.
- B. Contractor assumes responsibility for the correct direction of rotation required by the equipment drives. In the event of damage due to reverse rotation, the equipment shall be repaired or replaced at no charge to the Owner.
1. Motors smaller than 3/4 horsepower (HP) shall be single phase, open capacitor type in accordance with NEMA standards wound for 115 volts, 60 Hertz, alternating current.

- Motors 1/6 horsepower (HP) and under may be split phase type. Motors one (1) horsepower and larger shall have nameplate rated minimum efficiency for the following table. Ratings shall be based on IEEE Test Procedure 112, Method B.
2. This specification addresses the mechanical and electrical design, electrical insulation system and testing requirements of Premium Efficiency Totally Enclosed Fan Cooled low voltage electric motors.
  3. All motors conform to the following provisions unless otherwise specified in the request for quotation and so stated on the purchase order.
  4. Motors in NEMA frames 143T through 445T are 3 phase, 60 Hertz, 230/460 volts. Frames 447T and larger are 460 volt. All frames are also available in 575 volt.
  5. Motors are suitable for continuous duty in ambient temperatures from -13°F to 104°F. Operating altitude is 3330 feet or less.
  6. All motors have a Service Factor of 1.15 with the exception of the 350 HP 2 and 6 poles, and the 450 HP 4 pole.
  7. All motors are in accordance with the latest revisions of NEMA Standard MG 1 and comply or exceed the applicable portions of the National Electrical Code, the Canadian Standards Association and Underwriters Laboratory.
  8. All motors supplied are the manufacturer's premium efficiency design. The nominal efficiency and the minimum guaranteed efficiency are stamped on the nameplate of the motor. All efficiency testing and labeling are done in accordance with the NEMA MG 1 standard.
  9. All motors are capable of developing NEMA Design B locked rotor and pull up torque with 90% of rated voltage applied.
  10. Conductors have increased cross-sectional area for improved efficiency. Low-loss, electrical-grade silicon steel is used with interlamination insulation suitable for the manufacturer's recommended burnout temperature.
  11. The insulation system is inverter grade to meet NEMA MG 1 Part 31.40.4.2. A Class B rise at a 1.15 service factor (445T frame and below) with a Class F plus insulation system. Motors are multi-dipped and baked in Class H varnish.
  12. Stator windings are copper. Motor leads are stranded copper and are permanently identified and are brought out into the motor terminal box through a neoprene gasket.
  13. Dual voltage motors 7.5 HP and larger are capable of Across the Line, Wye-Start Delta Run starting on both high and low voltages, and Part Winding start on the low voltage. The 447T frame and larger are capable of Across the Line, Wye-Start Delta Run starting and Part Winding start on the high voltage.
  14. Stator frame and end brackets are a minimum of grade 25 cast iron construction or steel construction. The terminal box volume is one size larger than NEMA requirements and rotatable in 90o increments. External cooling fans are non-sparking corrosion resistant material. Drain holes (Qty. 2) are provided at the lowest points in the motor frame. A forged shouldered eyebolt is provided for lifting (180 frame and larger). Fosheda lip seal (440 frame and below) or shaft slinger is supplied on the drive end. Bearings are either ball bearings or cylindrical roller bearings. Bearings are selected to provide a L-10 life of 40,000 hours with an external load per NEMA MG 1-14 and a L-10 life of 100,000 hours in direct coupled applications. The motor nameplate is stamped on 304 stainless steel and fastened to the motor frame with four stainless steel drive pins. All hardware is zinc-dichromate plated. The motor is dynamically balanced to 0.1 inch per second. Motors are capable of all positioning, mounting and operation.
  15. NEMA Publication MG 1-1993 Revision 1. Testing per NEMA MG 1-12 (IEEE 112 Test Standard, Method B with segregated loss analysis). All motors are given a routine test per NEMA MG 1, Section 12. Class F insulation system is UL Safety Standard 1004 recognized. Frame assignment per NEMA MG 1-13.

Motor Size (Horsepower)	Minimum Required Efficiency	Motor size (Horsepower)	Minimum Required Efficiency
1	85.5	30	93.6
1.5	86.5	40	94.1
2	86.5	50	94.5
3	89.5	60	95
5	89.5	75	94.5
7.5	91.7	100	94.5
10	91.7	125	95.4
15	92.4	150	95.8
20	93	200	96.2
25	93.6	250	96.2

- C. Each motor, one (1) horsepower (HP) or larger, or motor driven equipment, one (1) horsepower (HP) or larger shall have a composite power factor (PF) rating of ninety (90) percent to 100 percent when the driven equipment is operating at the design duty defined on the drawings. Power factor correction devices shall be provided to meet the stated criteria. Refer to Section 26 29 23 and the contract drawings for motors controlled by variable frequency drives.
- D. Devices such as capacitors, or equipment such as solid state power factor controllers, shall be provided as part of the motor or item of motor driven equipment when required for power factor correction. Devices shall be completely mounted and wired to the motor terminal except as follows:
1. For a motor or motor driven equipment requiring other than across-the-line starting, power factor (PF) correcting capacitors, or other equipment, shall be connected to motor terminals via a contractor (controller) with a 120 volt alternating current (VAC) coil. The 120 volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contractor (controller) used to establish the "run" operating mode for the motor driven equipment.
  2. For two (2) speed motors, power factor (PF) shall be corrected at each speed via separate groups of capacitors or other equipment for each speed. Each group of PF correcting components shall be connected to motor terminals via a separate contractor (controller) with a 120 volt alternating current (VAC) coil. Each 120 volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contractor or controller used to establish "run" operations at each speed.
- E. Shop drawings, shall include complete motor nameplate data and at least the following:
1. Full Load Amperes (FLA) without power factor correction.
  2. Full Load Amperes (FLA) with power factor correction.
  3. Power Factor (PF) when operating without power factor (PF) correction at rated full load or maximum capacity.
  4. Power Factor (PF) when operating with power factor (PF) correction at rated full load or maximum capacity.
- F. All motors operated on variable frequency drives shall be equipped with maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro

fibers to discharge electrical shaft currents within the motor and/or its bearings. The shaft bearing protection ring shall be Aegis Model SGR.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION, STARTUP AND SYSTEM TESTING

- A. Installation, startup and system testing shall be done in strict accordance with manufacturer's written instructions, approved submittals, referenced codes and standards and Section 26 05 05 – Starting of Systems and Training.
- B. Where manufacturer's services are specified, the manufacturer's representative shall inspect the installation prior to and be present during system startup and testing.
- C. Systems shall not be operated unless all system components have been properly installed and tested, and all system monitoring and controls have been properly commissioned and are deemed functional by the Controls Contractor.

END OF SECTION 23 00 00

## SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 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 NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.
- C. Comply with IEEE 519. Provide input filtering as required to meet criteria.

#### 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 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
  - 1. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

## 2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

## 2.5 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. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.
  - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Pre-lubricated, anti-friction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. 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 23 05 13

## SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Metal pipe hangers and supports.
  - 2. Pipe hangers - metal, trapeze type.
  - 3. Strut support systems - metal, rod type.
  - 4. Pipe stands.
  - 5. Thermal hanger-shield inserts.
  - 6. Fastener systems.
  - 7. Equipment stands.
  - 8. Equipment supports.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
  - 1. Trapeze pipe hangers.
  - 2. Metal strut support systems.
  - 3. Rooftop-mounted strut support systems.
  - 4. Pipe stands.
  - 5. Equipment supports.

### PART 2 - PRODUCTS

#### 2.1 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: Pre-galvanized, 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.

2.2 PIPE HANGERS - METAL, TRAPEZE TYPE

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

2.3 STRUT SUPPORT SYSTEMS - METAL, ROD TYPE

- A. Description: Factory-fabricated pipe-support assembly made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
- B. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
- C. Struts: Continuous slotted carbon-steel or extruded-aluminum channel with inturred lips.
- D. Strut Width: Selected for applicable load criteria.
- E. Strut Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- F. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

2.4 PIPE STANDS

- A. General Requirements: Shop-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Pipe Stand - Single Base, Single Pipe, Low Profile:
1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
  2. Base: Single, vulcanized rubber.
  3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch (12-mm) rods.
  4. Horizontal Member: Adjustable-height, galvanized-steel pipe support channels.
  5. Pipe Supports: Roller or Strut clamps.
  6. Hardware: Galvanized steel.
  7. Height: 12 inches (300 mm) above roof.

C. Pipe Stand - Multiple Pipe, Low Profile:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber.
3. Vertical Members: Two or more, galvanized-steel channels.
4. Horizontal Members: One or more, adjustable-height, galvanized-steel pipe support.
5. Pipe Supports: Roller or Strut clamps.
6. Hardware: Galvanized steel.
7. Height: 12 inches (300 mm) above roof.

2.5 THERMAL HANGER-SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig (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-psig (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.

2.6 FASTENER SYSTEMS

- A. 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 steel.
  2. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT STANDS

- A. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.
- B. Foot Material: Rubber or polypropylene.
- C. Rails Material: Hot dip galvanized carbon steel.
- D. Wind/Sliding Load Resistance: Up to 100 mph (44 mps) minimum.

2.8 EQUIPMENT SUPPORTS

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

## 2.9 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. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. 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 in accordance with ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.

- C. Strut System Installation: Metal. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- D. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
  - 1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation:
  - 1. Fabricate from welded-structural-steel shapes.
  - 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
  - 3. Grouting: Place grout under supports for floor-mounted equipment and make bearing surface smooth.
  - 4. Provide lateral bracing, to prevent swaying.
- I. 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.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. 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.
- L. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. 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.
- N. 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.
5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

### 3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for 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.

### 3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

### 3.5 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" or Section 099123 "Interior Painting".
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

### 3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use metal trapeze pipe hangers for VRF piping applications.
- G. Use copper-plated pipe hangers and copper 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 non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
  - 2. 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.
  - 3. 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.
  - 4. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
  - 5. 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.
- 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. 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. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  5. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  6. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  7. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. 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.

- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

## SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed-restrained-spring isolators.
5. Pipe-riser resilient support.
6. Resilient pipe guides.
7. Elastomeric hangers.
8. Spring hangers.
9. Snubbers.
10. Restraints - rigid type.
11. Restraints - cable type.
12. Restraint accessories.
13. Post-installed concrete anchors.
14. Concrete inserts.
15. Restrained isolation roof-curb rails.

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.

#### 1.3 DEFINITIONS

- A. Designated Seismic System: An HVAC component that requires design in accordance with ASCE/SEI 7, Ch. 13, and for which the Component Importance Factor is greater than 1.0.
- B. IBC: International Building Code.

#### 1.4 ACTION SUBMITTALS

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

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.
3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-force-restraint component.
4. 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 ICC-ES product listing.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

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.
  - g. Refer to drawing S-001 for wind and seismic load information.
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 evaluation service member of ICC-ES, 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.
- D. Refer to structural drawing S-001 for wind & seismic load information.

## PART 2 - PRODUCTS

### 2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
- 1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
  - 2. Size: Factory or field cut to match requirements of supported equipment.
  - 3. 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. Infused nonwoven cotton or synthetic fibers.
  - 6. Load-bearing metal plates adhered to pads.
  - 7. Sandwich-Core Material: Resilient and elastomeric.
    - a. Surface Pattern: Smooth, ribbed, or waffle pattern.
    - b. Infused nonwoven cotton or synthetic fibers.

### 2.2 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.

## 2.3 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.

## 2.4 HOUSED-RESTRAINED-SPRING ISOLATORS

### A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

- 1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
  - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
  - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
- 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

## 2.5 PIPE-RISER RESILIENT SUPPORT

### A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch-Thick Neoprene:

- 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
- 2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

## 2.6 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch-Thick Neoprene:

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

## 2.7 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.

## 2.8 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.

## 2.9 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.
2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.10 RESTRAINTS - RIGID TYPE

- A. 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.

2.11 RESTRAINTS - CABLE TYPE

- A. 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.
- B. Restraint cable assembly with 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.

2.12 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.

2.13 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 for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:
  - 1. 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 wind-load 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.
- 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.

#### 2.14 CONCRETE INSERTS

- A. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC408 testing.
- B. Comply with ANSI/MSS SP-58.

#### 2.15 RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
- B. Upper Frame: To provide continuous support for equipment and to be captive to resiliently resist seismic and wind forces.
- C. Lower Support Assembly: To be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. Lower support assembly to have a means for attaching to building structure and a wood nailer for attaching roof materials, and to be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Mount adjustable, restrained-spring isolators on elastomeric vibration isolation pads and provide access ports, for level adjustment, with removable waterproof covers at all isolator locations. Locate isolators so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
- D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.
- E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counter flashed over roof materials.

### PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application 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 present and future static, wind load, and seismic loads within specified loading limits.

### 3.3 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. Install seismic-restraint, and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES 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 o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

H. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

I. Install seismic-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. 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. 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. 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 re-

quirements in Section 232113 "Hydronic Piping" and Section 232300 "Refrigerant Piping" for piping flexible connections.

### 3.5 ADJUSTING

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

### 3.6 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. 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 post connection 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.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 230548

## SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Pipe labels.
  - 3. Duct labels.

#### 1.3 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.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system; to include in maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
  - 1. Material and Thickness: aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Letter Color: White.
  - 3. Background Color: Black.
  - 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 up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters 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. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. 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.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

## 2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
  1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
  2. Lettering Size: Size letters according to ASME A13.1 for piping.

## 2.3 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.

- C. Background Color: Black.
- D. Maximum Temperature: Able to withstand temperatures 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 up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters 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. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
  - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

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

#### 3.2 GENERAL INSTALLATION 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 acoustic ceilings and similar concealment.

#### 3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

#### 3.4 PIPE LABEL INSTALLATION

- A. 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. Near each valve and control device.
  - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
  - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
  - 1. Refrigerant Piping: White letters on a safety-purple background.
  - 2. Condensate Drain Piping: White letters on a safety-green background.

### 3.5 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
  - 1. White on Green: For cold-air supply ducts.
  - 2. Black on Yellow: For outside- and return-air ducts.
  - 3. White on Blue: For exhaust-air ducts.
- B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION 23 05 53

## SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

### 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. Balancing Air Systems:
    - a. Constant-volume air systems.
  - 2. Testing, Adjusting, and Balancing Equipment:
    - a. Motors.
    - b. Condensing units.

#### 1.3 DEFINITIONS

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

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 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 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

- C. Strategies and Procedures Plan: Within 30 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 30 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.

#### 1.5 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
  - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
  - 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

#### 1.6 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. 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, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
  - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. 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 HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    - b. Duct systems are complete with terminals installed.
    - c. Volume, smoke, and fire dampers are open and functional.
    - d. Clean filters are installed.
    - e. Fans are operating, free of vibration, and rotating in correct direction.
    - f. Variable-frequency controllers' startup is complete, and safeties are verified.
    - g. Automatic temperature-control systems are operational.
    - h. Ceilings are installed.
    - i. Windows and doors are installed.
    - j. Suitable access to balancing devices and equipment is provided.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
  - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation" and Section 23 07 19 "HVAC Piping Insulation."

- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, 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 BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

### 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
  - 1. Measure total airflow.
    - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.
  3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
  4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
  2. Adjust submain and branch duct volume dampers for specified airflow.
  3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
  2. Measure inlets and outlets airflow.
  3. Adjust each inlet and outlet for specified airflow.
  4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
  2. Re-measure and confirm that total airflow is within design.
  3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
  4. Mark all final settings.
  5. Test system in economizer mode. Verify proper operation and adjust if necessary.
  6. Measure and record all operating data.
  7. Record final fan-performance data.

### 3.6 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
  2. Air Outlets and Inlets: Plus or minus 10 percent.

- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### 3.7 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. Fan 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. Data for terminal units, including manufacturer's name, type, size, and fittings.
  - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
  - 15. Test conditions for fans and pump performance forms including the following:
    - a. Settings for outdoor-, return-, and exhaust-air dampers.
    - b. Conditions of filters.
    - c. Cooling coil, wet- and dry-bulb conditions.
    - d. Face and bypass damper settings at coils.
    - e. Fan drive settings including settings and percentage of maximum pitch diameter.
    - f. Settings for supply-air, static-pressure controller.

- g. Other system operating conditions that affect performance.
- D. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
  - 1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Unit arrangement and class.
    - g. Discharge arrangement.
    - h. Sheave make, size in inches, and bore.
    - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    - j. Number, make, and size of belts.
    - k. Number, type, and size of filters.
  - 2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Sheave make, size in inches, and bore.
    - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
  - 3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.
    - b. Total system static pressure in inches wg.
    - c. Fan rpm.
    - d. Discharge static pressure in inches wg.
    - e. Filter static-pressure differential in inches wg.
    - f. Preheat-coil static-pressure differential in inches wg.
    - g. Cooling-coil static-pressure differential in inches wg.
    - h. Heating-coil static-pressure differential in inches wg.
    - i. Outdoor airflow in cfm.
    - j. Return airflow in cfm.
    - k. Outdoor-air damper position.
    - l. Return-air damper position.
    - m. Vortex damper position.
- E. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  - 1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F.
    - d. Duct static pressure in inches wg.
    - e. Duct size in inches.
    - f. Duct area in sq. ft.
    - g. Indicated airflow rate in cfm.

- h. Indicated velocity in fpm.
- i. Actual airflow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

F. Air-Terminal-Device Reports:

1. Unit Data:

- a. System and air-handling unit identification.
- b. Location and zone.
- c. Apparatus used for test.
- d. Area served.
- e. Make.
- f. Number from system diagram.
- g. Type and model number.
- h. Size.
- i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Air velocity in fpm.
- c. Preliminary airflow rate as needed in cfm.
- d. Preliminary velocity as needed in fpm.
- e. Final airflow rate in cfm.
- f. Final velocity in fpm.
- g. Space temperature in deg F.

END OF SECTION 23 05 93

## SECTION 23 07 13 - DUCT 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 duct services:
  - 1. Indoor supply and outdoor air.
  - 2. Indoor return air located in unconditioned space.
  - 3. Indoor, concealed oven exhaust.
  - 4. Indoor exhaust between isolation damper and penetration of building exterior.
- B. Related Sections:
  - 1. Section 23 07 19 "HVAC Piping Insulation."
  - 2. Section 23 31 13 "Metal Ducts" for duct liners.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- 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 insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
  - 3. Detail application of field-applied jackets.
  - 4. Detail application at linkages of control devices.

#### 1.4 INFORMATIONAL SUBMITTALS

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

## 1.5 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 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.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

## 1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

## 1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required. 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 "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum 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 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. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 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. CertainTeed Corporation.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. Knauf Insulation.
    - d. Manson Insulation Inc.
    - e. Owens Corning.
- F. 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. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

## 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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

## 2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perms at 43-mil dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perms at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms sat 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

## 2.4 SEALANTS

A. 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.
4. Color: Aluminum.

## 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

## 2.6 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.

## 2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

## 2.8 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inchwide with wing seal or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inchwide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
  - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
  - c. Adhesive: Recommended by hanger manufacturer. 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. Comply with the following requirements:
  - a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
  - b. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
  - c. Adhesive: Recommended by hanger manufacturer. 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. Comply with the following requirements:
  - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
  - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
  - c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

- a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- D. Wire: 0.080-inch nickel-copper alloy.

## 2.9 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, 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 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. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 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 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-wide strips of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches 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 beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

### 3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
  - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
  - 4. Seal jacket to wall flashing with flashing sealant.
- 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.
  - 1. Comply with requirements in **Section 07 84 13 "Penetration Firestopping."**

### 3.5 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 and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
  - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches 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 over compress 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 from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch 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 at 18-foot 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.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches 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-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

### 3.6 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 laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

### 3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor supply and outdoor air.
2. Indoor return air located in unconditioned space.
3. Indoor, concealed oven exhaust.
4. Indoor exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
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.

C. Building Support Space 101 shall be considered an unconditioned space.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Supply- and outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Return-air duct located in unconditioned space insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed oven exhaust-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Exhaust-air duct between isolation damper and penetration of building exterior insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

END OF SECTION 23 07 13

## SECTION 230900 - BUILDING AUTOMATION AND TEMPERATURE CONTROL SYSTEM

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified:

#### 1.3 COMMISSIONING

- A. All building energy-related systems shall be commissioned in order to verify and ensure that fundamental building elements and systems are installed, constructed, calibrated to operate, and perform according to the Owner's Project Requirements, Basis of Design, and Construction Documents.
- B. Refer to Divisions 1 and 23 commissioning specifications for additional information.

#### 1.4 SCOPE

- A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
- B. The BAS shall be a Web based system communicating over the building owners Local Area Network (LAN). Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BAS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN. TCP/IP connections and addresses shall be provided by the owner for connection of supervisory panels to the County network.
- C. The primary desktop and laptop interface will be via a standard Web Browser such as Internet Explorer or Chrome. BAS contractor shall provide software license(s) for BAS WEB access for a minimum of twenty concurrent users.
- D. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that

the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.

- E. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- F. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.
- G. Air handling unit control/end devices shall be factory installed by the air handling unit manufacturer. Controls contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the drawings.
- H. The Controls Contractor shall coordinate with the AHU manufacturer to integrate the unit into the building automation system. The BAS Controls Contractor shall furnish and field install any required field I/O and interfaces as required for functions as indicated on the drawings.
  - 1. RTU smoke isolation dampers and control dampers shall be provided by the RTU manufacturer.
    - a. To maintain the ETL smoke rating, the RTU manufacturer shall also provide the actuators for the smoke isolation dampers.
    - b. All other RTU control damper actuators shall be furnished BAS manufacturer and field installed by the BAS Controls Contractor.
- I. Variable Frequency Drives (VFDs):
  - 1. All pump VFDs, and VFDs for fans not in air handling units, shall be furnished and installed (set in place) by the BAS provider.
  - 2. Air handling unit VFDs shall be furnished and installed by the air handling unit manufacturer.
  - 3. Power wiring for VFDs shall be provided under Division 26.
  - 4. Refer to Section 230550 "Variable Frequency Drives".
- J. Lighting Panel BAS Scope of Work
  - 1. BAS Controls Contractor shall provide all necessary materials and labor, including integration devices, to integrate with the lighting panels (LP) as shown on the electrical drawings.
- K. BAS provider shall provide IT cabling and network between devices, controllers and building controllers so that a complete BAS is installed, functional and accessible via tie into the BAS network from a single location during TAB and commissioning. BAS network and cabling shall be compliant with and compatible with the Owner's IT department requirements so that BAS may be connected to an Owner's switch(s) once that system is complete.

## 1.5 INTERFACE REQUIREMENTS

- A. The BAS contractor shall provide all necessary hardware and software to implement a complete and fully functional building automation system as indicated on the drawings and specifications. The system shall provide the ability to monitor, override, adjust setpoints, and support real-time bidirectional data exchange between all system components. Integration means the ability to monitor, override, change set points, and provide real-time bi-directional dynamic data exchange between the new control system and the existing BAS hardware and software.

- B. All new control points, monitoring points and software points shall be available for monitoring and adjustment at any computer, with current copy of Microsoft Internet Explorer software (Release 6.0 or later), that is connected to the County LAN.
- C. All new building software and databases shall be archived on the hard drive at the BAS server. In the event that any building controller should lose its program that controller's archived software program shall be downloaded across the BAS network from the BAS server to the respective building controller.
- D. The BAS contractor will provide all necessary hardware, software, and labor to allow communication with all any computer, with current copy of Microsoft Internet Explorer (Release 6.0 or later), that is connected to the LAN.
- E. Integrity of the existing BAS shall be maintained during installation.

#### 1.6 WORK BY OTHERS

- A. Electrical Contractor provides:
  - 1. 120V power to all BAS and/or Temperature control panels. Where not shown on plans, locations shall be determined by the BAS contractor and coordinated with the Architect and electrical contractor.
  - 2. Wiring of all power feeds through all disconnect starters to electrical motor.
  - 3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BAS manufacturer.
  - 4. Wiring of electrical sub-metering devices furnished by BAS manufacturer.
- B. Control Devices for Installation by Installers
  - 1. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
  - 2. Deliver the following to duct fabricator and installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
    - a. Airflow sensors, switches and stations
    - b. Pressure sensors.
  - 3. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
    - a. DDC control valves
  - 4. Deliver the following to electrical installers for installation. Include installation instructions to Installer and supervise installation for compliance with requirements.
    - a. Meters/Sub-Metering Devices
- C. Communication Interface to Equipment with Integral Controls
  - 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
  - 2. Equipment to Be Connected:
    - a. Computer-room air-conditioning units
    - b. Emergency engine generators
    - c. Packaged rooftop air handling unit controllers
    - d. Refrigerant monitoring
    - e. Split-system air-conditioners
    - f. Variable-frequency controllers

- g. Leak detection monitoring systems
  - h. Server exhaust fans
- D. Communication Interface to Other Building Systems:
  - 1. DDC system shall have a communication interface with systems having a communication interface.
  - 2. Systems to Be Connected:
    - a. Access controls.
    - b. Elevators.
    - c. Fire-alarm system
    - d. Lighting controls. BAS shall connect to all Lighting Control panels and contactors for lighting control. Refer to the electrical drawings for location and quantity.
    - e. Power monitoring.
- E. Test, Adjust and Balance:
  - 1. The BAS contractor shall cooperate with the air and water testing, adjusting and balancing (TAB) contractor in the performance of their work as required or directed, including calibration of all sensors and devices.
  - 2. The BAS contractor shall work with the air and water testing, adjusting and balancing (TAB) contractor and commissioning agent (CxA) to utilize the TAB certified measuring instruments to verify BAS temperature and humidity readings as applicable and provide any adjustments in the BAS programming to modify the reading of the BAS sensor to match the TAB reading.
- F. Commissioning
  - 1. BAS contractor shall work with the Commissioning Agent in the performance of their work as required or directed.
  - 2. Each system upon completion shall be tested in the presence of the Commissioning Agent and shall be shown to be in satisfactory condition.
  - 3. During this test period, the BAS Contractor shall make all necessary adjustments.
  - 4. General operating tests shall cover such time as is necessary to demonstrate that the entire equipment is functioning in accordance with specifications.
  - 5. BAS Contractor shall furnish all instruments, test equipment and personnel that are required for tests.
  - 6. It will be the BAS Contractor's responsibility to schedule the above tests with the Architect and Commissioning Agent.
  - 7. Refer to PART 3 – EXECUTION for additional requirements.

## 1.7 ACTION SUBMITTALS

- A. Product Data: For each type of product include the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation, operation and maintenance instructions including factors effecting performance.
  - 5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

- a. Gateways.
  - b. Routers.
  - c. DDC controllers.
  - d. Enclosures.
  - e. Electrical power devices.
  - f. UPS units.
  - g. Accessories.
  - h. Instruments.
  - i. Control damper actuators.
  - j. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
  7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:

1. General Requirements:
  - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
  - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
  - c. Drawings Size: 11x17.
2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:
  - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
  - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
  - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
  - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
  - e. Network communication cable and raceway routing.
  - f. Information, drawn to scale, of 1/4"=1'-0".
  - g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
6. Schematic drawings for each controlled HVAC system indicating the following:
  - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
  - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
  - c. A graphic showing location of control I/O in proper relationship to HVAC system.
  - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
  - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
  - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
  - g. Narrative sequence of operation.

- h. Graphic sequence of operation, showing all inputs and output logical blocks.
  - 7. Control panel drawings indicating the following:
    - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
    - c. Front, rear, and side elevations and nameplate legend.
    - d. Unique drawing for each panel.
  - 8. DDC system network riser diagram indicating the following:
    - a. Each device connected to network with unique identification for each.
    - b. Interconnection of each different network in DDC system.
    - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
    - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
  - 9. DDC system electrical power riser diagram indicating the following:
    - a. Each product requiring power with associated requirements (volts/phase/hertz/amperes/connection type) listed for each.
  - 10. Monitoring and control signal diagrams indicating the following:
    - a. Control signal cable and wiring between controllers and I/O.
    - b. Point-to-point schematic wiring diagrams for each product.
    - c. Control signal tubing to sensors, switches and transmitters.
    - d. Process signal tubing to sensors, switches and transmitters.
  - 11. Color graphics indicating the following:
    - a. Itemized list of color graphic displays to be provided for each system.
    - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    - c. All visible points to be displayed.
    - d. Intended operator access between related hierarchical display screens.
- C. System Description:
  - 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
  - 2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
  - 3. System and product operation under each potential failure condition including, but not limited to, the following:
    - a. Loss of power.
    - b. Loss of network communication signal.
    - c. Loss of controller signals to inputs and outpoints.
    - d. Operator workstation failure.
    - e. Server failure.
    - f. Gateway failure.
    - g. Network failure
    - h. Controller failure.
    - i. Instrument failure.
    - j. Control damper and valve actuator failure.
  - 4. Complete bibliography of documentation and media to be delivered to Owner.
  - 5. Description of testing plans and procedures.
  - 6. Description of Owner training.

## 1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system 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. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
    - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
    - c. As-built versions of submittal Product Data.
    - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
    - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
    - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    - g. Engineering, installation, and maintenance manuals that explain how to:
      - 1) Design and install new points, panels, and other hardware.
      - 2) Perform preventive maintenance and calibration.
      - 3) Debug hardware problems.
      - 4) Repair or replace hardware.
    - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
    - i. Backup copy of graphic files, programs, and database on electronic media such as digital media.
    - j. List of recommended spare parts with part numbers and suppliers.
    - k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
    - l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
    - m. Licenses, guarantees, and warranty documents.
    - n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
    - o. Owner training materials.

## 1.9 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 20 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.
- B. The manufacturer shall provide onsite, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS.
- C. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise

and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project.

- D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- E. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology and extend new field panels on a previously installed network.
- F. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall 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.

#### 1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
  - 1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
  - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
    - a. Install updates only after receiving Owner's written authorization.
  - 3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
  - 4. Warranty Period: From date of Substantial Completion.
    - a. One-year parts and labor.
    - b. Three-year parts.
    - c. For Gateway: One-year parts and labor warranty for each.
- B. The on-line support services shall allow the local BAS subcontractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

#### 1.11 IDENTIFICATION

- A. Identify control wires with a distinctive number on a nonconducting tag attached to each end or at junction points or by color coding of that wire or tube. Designate on control diagram the identifying color and/or number or other identifying designation used.
- B. Identify all control equipment and devices, including panels, controllers, valves, and automatic dampers, firestats, etc., by a method approved by the Architect. Designations shall match those used on control diagrams and shop drawings.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Johnson Controls Inc. (Metasys). Bertie County preferred control vendor
- B. Basis-of-Design Product: Subject to compliance with requirements, provide a building automation and temperature control system by Johnson Controls.

### 2.2 GENERAL DESCRIPTION

- A. The Building Automation System (BAS) shall use an open architecture. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Automation shall consist of the following:
  - 1. Standalone Network Control Engine (NCE)
  - 2. Field Equipment Controller(s)
  - 3. Input/Output Module(s)
  - 4. Local Display Device(s)
  - 5. Distributed User Interface(s)
  - 6. Network processing, data storage and communications equipment
  - 7. Other components required for a complete and working BAS
- C. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

### 2.3 PERFORMANCE REQUIREMENTS

- A. Delivery of Selected Control Devices: Deliver to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. Delegated Design, Qualified Professional: Engage a qualified professional to design BAS system to satisfy requirements indicated.
  - 1. System Performance Objectives:
    - a. BAS system manages HVAC systems.
    - b. BAS system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
    - c. BAS system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
    - d. BAS system operates while unattended by an operator and through operator interaction.

- e. BAS system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.
- C. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; 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.
- D. BAS System Speed:
  - 1. Response Time of Connected I/O:
    - a. Update AI point values connected to BAS system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
    - b. Update BI point values connected to BAS system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
    - c. AO points connected to BAS system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
    - d. BO point values connected to BAS system to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
  - 2. Display of Connected I/O:
    - a. Update and display analog point COV connected to BAS system at least every 10 seconds for use by operator.
    - b. Update and display binary point COV connected to BAS system at least every 10 seconds for use by operator.
    - c. Update and display alarms of analog and digital points connected to DDC system within 45 seconds of activation or change of state.
    - d. Update graphic display refresh within eight seconds.
    - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.
- E. Network Bandwidth: Design each network of BAS system to include spare bandwidth with BAS system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:
  - 1. Level 1 Networks: 20.
  - 2. Level 2 Networks: 20
  - 3. Level 3 Networks: 10.
- F. BAS Data Access:
  - 1. When logged into the system, operator able to also interact with any BAS controllers connected to BAS system as required for functional operation of BAS system.
  - 2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
- G. Future Expandability:
  - 1. BAS system size shall be expandable to an ultimate capacity of at least 1.25 times total I/O points indicated.
  - 2. Design and install system networks to achieve ultimate capacity with only addition of BAS controllers, I/O, and associated wiring and cable. Design and install initial network

- infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.
- H. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Energy:
    - a. Thermal: Within 5 percent of reading.
    - b. Electric Power: Within 5 percent of reading.
    - c. Requirements indicated on Drawings for meters not supplied by utility.
  2. Flow:
    - a. Air: Within 2 percent of design flow rate.
    - b. Air (Terminal Units): Within 10 percent of design flow rate.
    - c. Natural Gas: Within 5 percent of design flow rate.
    - d. Water: Within 2 percent of design flow rate.
  3. Gas:
    - a. Carbon Dioxide: Within 50 ppm.
  4. Moisture (Relative Humidity):
    - a. Air: Within 5 percent RH.
    - b. Space: Within 5 percent RH.
    - c. Outdoor: Within 5 percent RH.
    - d. Level: Within 2 percent of reading.
  5. Pressure:
    - a. Air, Ducts and Equipment: 1 percent of instrument range.
    - b. Space: Within 1 percent of instrument range.
    - c. Water: Within 1 percent of instrument range.
  6. Speed: Within 5 percent of reading.
  7. Temperature, Dew Point:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
    - c. Outdoor: Within 3 deg F
  8. Temperature, Dry Bulb:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
    - c. Outdoor: Within 1 deg F.
    - d. Chilled Water: Within 1 deg F.
    - e. Heating Hot Water: Within 1 deg F.
    - f. Temperature Difference: Within 0.25 deg F
  9. Temperature, Wet Bulb:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
    - c. Outdoor: Within 1 deg F.
- I. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:
1. Current:
    - a. Milliampere: Nearest 1/100th of a milliampere.
    - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
  2. Energy:
    - a. Electric Power:
      - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.

- 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
    - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
  - b. Thermal, Rate:
    - 1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.
    - 2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
  - c. Thermal, Usage:
    - 1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.
    - 2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.
3. Flow:
  - a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
  - b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm.
  - c. Natural Gas: Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.
  - d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
4. Moisture (Relative Humidity):
  - a. Relative Humidity (Percentage): Nearest 1 percent.
5. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
6. Speed:
  - a. Rotation (rpm): Nearest 1 rpm.
  - b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
7. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
8. Pressure:
  - a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
  - b. Space: Nearest 1/100th of an inch water closet.
  - c. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.
9. Temperature:
  - a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
  - b. Outdoor: Nearest degree.
  - c. Space: Nearest 1/10th of a degree.
  - d. Chilled Water: Nearest 1/10th of a degree.
  - e. Heating Hot Water: Nearest degree.
10. Vibration: Nearest 1/10th of an inch per second.
11. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.

- J. Environmental Conditions for Controllers, Gateways, and Routers:
  - 1. Products shall operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
    - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
  - 2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:
- K. Environmental Conditions for Instruments and Actuators:
  - 1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
  - 2. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled, and/or ventilated as required by instrument and application.
- L. Electric Power Quality:
  - 1. Power-Line Surges:
    - a. Protect susceptible BAS system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
    - b. Do not use fuses for surge protection.
    - c. Test protection in the normal mode and in the common mode, using the following two waveforms:
      - 1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
      - 2) 8-by-20-microsecond waveform with a peak voltage of 1000 V and a peak current of 500 A.
  - 2. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.
- M. Backup Power Source:
  - 1. Serve BAS system products that control HVAC systems and equipment served by a backup power source also from a backup power source.
- N. UPS:
  - 1. BAS system products powered by UPS units are to include the following:
    - a. Servers.
    - b. Gateways.
    - c. DDC controllers.
    - d. Desktop workstations.
- O. Continuity of Operation after Electric Power Interruption:
  - 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

## 2.4 BAS ARCHITECTURE

### A. Automation Network

1. The BAS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Utilize existing application and data server as required for systems operation.
2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
3. Network Control Engine (NCE) shall reside on the automation network.
4. The automation network will be compatible with other campus-wide networks. Where indicated, the automation network shall be connected to the campus network and share resources with it by way of standard networking devices and practices.

### B. Control Network

1. Network Control Engine (NCE) shall provide supervisory control over the control network.
2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 38,400 baud.
3. DDC Controllers shall reside on the control network
4. Wireless communication between DDC controllers is acceptable. All sensors shall be wired.

### C. Dedicated Web Based User Interface

1. The BAS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. Real-time control functions, including scheduling, history collection and alarming, shall be resident in the BAS Network Engines and Data Server to facilitate greater fault tolerance and reliability.
2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BAS Contractor and by other third-party applications suppliers, including but not limited to Microsoft Office Applications. Specifically, it must be implemented to conform to the following interface standards.
  - a. Edge or Google Chrome or Safari for user interface functions.
  - b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences and other necessary building management functions.
  - c. Microsoft Outlook or other e-mail programs for supplemental alarm functionality and communication of system events, and reports.
  - d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.
3. PC Hardware/Software – The personal computer(s) shall be configured as specified in the Computing Hardware and Software section.
4. Provide one operational device as herein specified and located on plans.
5. Mobile, Web Based, User Interface (MUI) General
  - a. All functionality as outlined within this section shall be provided as a standard catalog product software suite from the BAS manufacturer. Custom functionality development to meet these requirements is not acceptable.
  - b. The mobile, web-based, user interface shall be HTML5-compliant and provide access to the system from smartphones, tablets, portable and desktop computers. User Interfaces that require software installation on the client device (e.g. Java, Microsoft Silverlight®, Adobe® Flash®), or software downloads from an online app store shall not be acceptable for these purposes.

- c. The mobile user interface shall provide system operators with a simple space/zone/location-based navigation approach to finding information, including the ability to search for any location by name and to bookmark a location in a standard browser.
- d. The mobile user interface shall organize and display information using customer specific locations and spaces. At a minimum, the user interface shall provide:
  - 1) Organization of all space, equipment and point information in a familiar way (using standard equipment names and location descriptions), reducing the need for extensive training prior to use.
  - 2) A navigation mechanism or tree for users to select the specific location or space for accessing information – only spaces and locations in the navigation tree or equipment serving that space, nothing more.
  - 3) The ability to search for and/or bookmark any location, space, or equipment by name for quick access to critical or troublesome areas.
  - 4) Application of the same navigation mechanisms across any client device (e.g. Smart phone, tablet, personal computer) for consistency and ease of use.
- e. The same user interface elements shall be accessible from any type of personal computer or mobile device running any type of operating system supported (e.g. iOS, Android, Windows®). It shall automatically adapt and optimize the display for the screen size and touch screen navigation.
- f. Navigation Trees
  - 1) A dedicated location-based navigation tree shall be provided as part of the user interface in order to navigate to specific places within the facility on a hierarchical basis (typ. Campus, Facility, Building, Wing, Floor, Room.)
  - 2) The location-based tree shall use place names familiar to the operator without training or familiarization regarding special codes and conventions utilized in the generation of the BAS.
  - 3) Clicking or tapping on a location name in the tree shall display the home page associated with the space and simultaneously expand the tree to display the next level of spaces below the one selected.
  - 4) Provide a means for qualified users to view an all hardware items navigation tree of devices connected to the BAS network in order to enable troubleshooting of equipment and communications.
  - 5) A click or tap on a device in the network tree shall display a dashboard for that device including information regarding related equipment and access to a separate focus view of commandable points associated with the piece of hardware. A click or tap on such a point shall display a control dialogue box allowing the user to modify or command that point as indicated. The dialog box shall contain an annotation box for describing why the action was taken or special circumstances that apply.
  - 6) Specific hardware and software types in the Network tree shall also include access to one or more the following views in their dashboard depending on hardware type or network element (e.g. MS/TP trunk):
    - a) Summary View
    - b) Diagnostic View
    - c) Network View
    - d) Trend View
  - 7) Provide a means to hide the Network Tree and return to the Spaces Tree at any time by clicking on the Spaces Icon above the tree.
  - 8) Provide a means to restrict user access to any space in the Spaces Tree and thereby prevent manipulation of equipment associated with the space.
- g. Dashboard Displays
  - 1) The user interface shall provide the ability to view equipment visualizations, floor plans, and/or other graphics on mobile or desktop client devices in a

- browser environment, without the need for additional plugins or software. Graphics shall be accessible via a space (for floorplans, campus maps, etc.) or equipment dashboard.
- 2) Standard dashboards shall be configured for each defined space including one of the following predefined or custom elements:
    - a) Equipment Serving Space
    - b) Potential Problem Areas
    - c) Equipment Summary
    - d) Graphic Display (if specified)
    - e) Schedule
  - 3) Standard dashboards shall be configured for each system or device (typ. mechanical or electrical equipment) including the following predefined or custom elements:
    - a) Trend
    - b) Equipment Activity Summary
    - c) Equipment Relationships Summary
    - d) Equipment Data
    - e) Graphic Display
    - f) Schedule
  - 4) Users with appropriate permissions shall have access to a Dashboards Manager that can change the display order of Summaries and Data elements, add or remove elements and apply custom dashboards layouts to equipment and space by type.
  - 5) Dashboard Manager shall apply dashboards to spaces or equipment based on the viewing platform (Desktop/Tablet or Phone) in order to tailor the user experience to the needs of the specific user base.
  - 6) Default dashboard displays by space and equipment type shall be created per the guidelines in this specification or by mutual agreement with the Owner's representative.
- h. Alarm Management
- 1) The user interface shall provide a single display of all potential issues in a facility including items currently in alarm, warning, override, out-of-service and offline.
  - 2) The user interface shall provide notification of new alarms, visually and audibly.
  - 3) The user interface shall provide the ability to view a summary of alarms, including a chart of the number of alarms in each of the defined alarm priority ranges. The priority ranges should be filterable.
  - 4) The user interface shall provide the capability to view multiple occurrences of the same alarm, ultimately providing the ability to acknowledge or discard all occurrences of the alarm in a single action.
  - 5) The user interface shall provide the capability to view, and filter on, all alarms present in a well-defined mechanical system using the equipment serving equipment relationships.
  - 6) The user interface shall provide the capability to acknowledge and discard all occurrences of at least 1000 alarms in one operation.
  - 7) The user interface shall provide the user with the understanding of what physical space is being affected when an alarm occurs. The user interface shall provide the ability to filter alarms by physical space affected when the alarm occurred.
  - 8) The user interface shall provide the capability to monitor alarms 24/7 without requiring an active login to the system, accessible via segregated web page. The user interface shall provide the capability to enable or disable the 24/7 alarm monitor mode if desired.

- 9) The user interface shall provide the capability to annotate alarms using a pre-defined selection list or by providing custom text.
- 10) The user interface shall provide the capability to filter down alarm list and bookmark the filtered list, allowing automatic filtering to be applied when the bookmark is accessed.
- 11) Provide a means to export a .csv or .pdf copy of the currently displayed alarm list.
- 12) Provide a means to set up an alarm escalation feature. If an alarm is not acknowledged or discarded by recipients within a user-selected time, the alarm shall be escalated to an additional set of recipients.
- i. Send Announcement
  - 1) Administrative users should have the ability to alert staff of planned outages in advance. The communication avenues should include:
    - a) Email
    - b) A message shown on the login screen
    - c) A banner shown to logged in users
- j. Equipment Activity Summary
  - 1) The user interface shall provide a filterable, single display, of all activity related to a specific piece of equipment including user changes, discarded user changes, pending alarms, discarded alarms, and acknowledged alarms for at least one year of historical data.
  - 2) Items shall be listed in timed order with the latest activity at the top of the list.
  - 3) Filters shall allow only specific activities for specific data points occurring within a specific time and date window to be displayed.
  - 4) Provide a means to export a .csv copy of the currently displayed summary by clicking or tapping on the export icon.
  - 5) Provide a means to create a custom trend graph containing the data shown in the currently displayed summary by tapping or clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
  - 6) Clicking on the information icon in front of any displayed activity listed in the summary shall expand the display to include the name of the user, server time, value prior to the activity, the ability to annotate the activity and a user selectable icon for displaying a trend graph of the point.
- k. Equipment Relationships Summary
  - 1) The user interface shall provide a summary of all equipment and spaces related to the operation of the system or device currently selected for viewing.
  - 2) The user interface shall include the capability to navigate to the home page of any related piece of equipment or space with a single click or tap on the desired element.
- l. Equipment Data Summary
  - 1) The user interface shall provide a summary of all data pertaining to a particular piece of mechanical or electrical equipment in a tabular format. Clicking or tapping on any value in the summary shall display a related command panel allowing the user to command, override, or change service condition of the point selected and to annotate such actions for future reference.
  - 2) Provide a means to export a .pdf copy of the report with a single click on the associated export icon.
- m. Equipment Serving Space Summary
  - 1) The user interface shall provide a summary of all mechanical and electrical equipment as defined in the points list that serves a selected space from the navigation tree.

- 2) The summary shall be capable of including a subset of the viewable points for each system representing the key elements of interest to operators without subjecting them to long lists of points irrelevant to basic operation.
  - 3) Clicking or tapping on any item in the summary shall navigate to the item's assigned home page in the user interface.
  - 4) Provide a means to view a custom trend of information contained in the summary with a single click of the trend icon residing in the title header.
  - 5) Provide a means to display specific systems and points by filtering equipment types desired.
  - 6) Because the data is intended to be a snapshot of the current conditions in the space it shall not dynamically update but a click or tap on the update icon at any time performs that function.
- n. Potential Problem Areas Summary
- 1) The user interface shall provide a summary of all points in the system related to the space that are not operating correctly (e.g. alarm, off normal or not communicating correctly) in order to provide the operator with a quick update on current conditions.
  - 2) The information shall include:
    - a) Point status (via color)
    - b) Point name
    - c) Value of the point when the summary was taken
    - d) Equipment that contains the offending point
    - e) Space that is served by that equipment
  - 3) Data points in the summary may be filtered by one or more types of off-normal condition (e.g. above setpoint, offline and overridden).
  - 4) The summary may be exported in .csv format for inclusion in spreadsheets or other documents.
- o. Equipment Summary
- 1) The user interface shall provide a summary that allows the user to compare all similar equipment that serves the space as well as downstream (child) spaces in order to evaluate conditions quickly and determine patterns for troubleshooting purposes.
  - 2) Each unique equipment type shall be selectable and display a representative set of values along with the space(s) being served by the device. Equipment types can be selected from a dropdown menu in the summary.
  - 3) Clicking or tapping on a selected device in the summary shall navigate to the home page for that piece of equipment while clicking or tapping a data point shall display the command panel for that point.
  - 4) Provide a means to export a .pdf copy of the currently displayed summary by clicking or tapping on the export icon.
  - 5) Provide a means to create a custom trend graph containing the data shown in the currently displayed summary by clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
  - 6) Provide a means to sort data within the summary by clicking on the desired column heading, allowing to sort from lowest to highest value or vice versa.
  - 7) Provide a means to edit the column types and column order within the summary to provide relevant information in accordance with Operators' preferences.
  - 8) Provide a means to link to an advanced search and reporting function directly from the Equipment Summary that will pre-populate the advanced report with the data from the Equipment Summary.
- p. User Defined Summaries

- 1) Provide the capability to view, command, and modify large quantities of similar data in summaries without the use of a secondary application (e.g. a spreadsheet). These summaries shall be generated automatically or user defined.
- q. Trend
  - 1) The user interface shall provide the capability to view historical trend data from multiple pieces of equipment in both bar and line formats.
  - 2) The user shall have the ability to navigate to a selection list of frequently viewed trends.
  - 3) Trend graphs shall have to ability to be smartly auto-generated based on equipment and space relationships.
  - 4) The user shall have the ability to view up to 3 graphs of differing units of measurement in a single screen and select which data points to plot on each to help with readability.
  - 5) Each graph shall include a dedicated selection icon to export a copy of the graphic and data in .pdf format or the data only as a .csv file.
  - 6) Trend graphs shall allow the plotting of non-trended point's default values.
  - 7) The user shall have the ability to add any trended to point a custom trend graph.
  - 8) The user shall have the ability to save trend graphs for reference later.
  - 9) The user shall be able to specify the duration of time and aggregation period for each trend line.
  - 10) The user shall have the ability to decide whether to show raw or aggregate trend data.
- r. Operator Access
  - 1) The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign "inherited" space permissions and the ability to assign user's space based access in bulk.
  - 2) The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign "inherited" space permissions and the ability to assign user's space based access in bulk.
- s. Graphics
  - 1) The user interface shall display an equipment visualization or graphic within the context of its associated space (building, floor, room, etc.) or equipment dashboard.
  - 2) Graphics shall include the ability to define individual information layers for operator selection in order to clarify systems status and simplify operation on mobile devices. Where desired a master layer may be defined to include important information about the facility on all graphic screens.
  - 3) Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.
  - 4) Provide a means to export a time stamped .pdf file of the graphic being viewed in order to communicate the current conditions in the space or the equipment being viewed and to provide a historic record.
  - 5) An integral graphic manager shall be provided including the following features and capabilities:
    - a) Creation and modification of graphics from any HTML5 capable browser without the need for additional plug-ins or software packages.

- b) Access to a full suite of pre-defined templates for air and water sourced HVAC applications as well as the ability to add custom templates as created for other use. Pre-aliased graphic templates may be defined and saved for repetitive representations of common mechanical and electrical equipment.
  - c) A full suite of pre-defined three dimensional symbols for mechanical and electrical systems as well as all line, text and shape tools required for integration into a graphic with zoom and pan capabilities on multiple platforms and in multiple browsers.
  - d) The ability to search and replace items in multiple graphics with a single command.
  - e) The ability to import and insert photos and images into the graphic.
  - f) The ability of the graphics manager to create and edit graphics including the ability to bind graphic elements to the values and conditions of system points in both an on-line and off-line mode.
  - g) The ability to create and import custom SVG symbols that can be selectable from the graphical palette and rendered at runtime.
- 6) As required, the BAS Contractor shall provide software licenses in the name of the owner for programming, configuration and graphics building tools to allow designated representatives to make changes, modifications or additions to the system. While future updates or revisions may require an update fee, the owner shall incur no additional cost if they choose not to update. Systems that require any annual or time-limited licensing fees shall not be permitted.
- t. Scheduling
  - 1) The user interface shall provide the capability to display, in a singular view, all of the effective schedules in the context of the space (building/floor/room, etc.) or equipment that the schedule effects. The software should have the ability to display an effective schedule, for the present, or a future date.
  - 2) The user interface shall provide a report of all schedules affecting a space or equipment. The report shall provide the user details of events that comprise the weekly schedule and exception schedule(s). The report shall provide a means of viewing individual breakout scheduling elements for Weekly Schedule, Exceptions and Default Commands.
  - 3) The user interface shall provide the capability to efficiently change or modify schedules in mass quantities. This includes the capability to add, in bulk, exceptions to schedules, in addition to assigning, in bulk, weekly schedules.
- u. Command and Control
  - 1) Provide a means to command system analog and binary points via a dropdown menu accessed by clicking or tapping on the value shown in any equipment summary or graphic display and completing the task in the resultant menu including an optional annotation.
  - 2) Commanding multiple points shall be possible on displays where multiple like system elements can be chosen.
  - 3) The user interface shall support users adding notes on their commands.
  - 4) The user interface shall support a choice of either permanent or temporary commands.
- v. Involvement
  - 1) The user interface shall provide in a single screen, a way to visualize all interactions (I.e. - commands, writes, references) with a single object.
  - 2) The interface shall provide the ability to filter out any interactions (i.e. commands, writes, references) that are not pertinent.
  - 3) The user interface shall allow seamless navigation between one object's Involvement view to another object's.
- w. System-Level Activity

- 1) The user interface shall provide a timeline view of all audits that occur in the system, including:
    - a) Logins attempts with user specified
    - b) Add, delete, modification of objects
    - c) Commands
  - x. Search
    - 1) Typing a text string in the Search box shall display a list of all occurrences of that string in the mobile user interface. When a string is represented in the description of a space or network element, selecting it shall display its default dashboard.
    - 2) Clicking or tapping on the Advanced Search Icon shall display the Advanced Search dialog box permitting the following:
      - a) Search by Space and Equipment, Equipment Definition or Network Reference
      - b) Filter the search by wildcard name or object type
      - c) Multi-selection of objects for commanding or the creation of reports including Trend, Alarm, Audit and Activity for a specific period of time
      - d) Creation of reports in PDF or CSV formats which can be instantaneously downloaded or emailed, or scheduled to be sent at Operator-selected intervals (daily/weekly/monthly)
  - y. Software Updates
    - 1) Users shall be notified when new software becomes available for download.
    - 2) Users shall be given brief information on what's to be expected in the update.
  - z. Offline Operation
    - 1) The mobile user interface shall have the ability to operate in an offline mode in order to create or edit graphics and dashboard elements.
    - 2) Content created offline shall be available to all authorized users for inclusion of an operating user interface later.
  - aa. Fault Detection
    - 1) Fault detection functionality shall be provided that identifies and displays building system-related faults and lists them color coded in order of severity. This software shall leverage defined rules and a semantic data model to ease configuration.
      - a) The building system fault engine shall run periodically against a minimum of seven days of historical data.
  - bb. Fault Triage
    - 1) Provide a means to display additional information on a particular fault along with corrective actions in the order of their likeliness to resolve the issue, a description of the fault, charting of supporting data, and an activity log to track progress of triage attempts. Functionality shall enhance the sorting order and information in the Faults display to introduce fault occurrences and durations to better drive the most problematic issues to the top of the list.
- D. Associated Application Components
1. Security/Passwords
    - a. Multiple-level passwords access protection shall be provided via roles and permissions. The feature will allow the system to base access on a user's job title or role and allow the user/manager access interface control, display, and database manipulation capabilities based on an assigned password.
    - b. Roles may be copied and altered to meet specific roles and permissions based on the particular policies.
    - c. The system shall allow each user to change his or her password at will.

- d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
- e. A maximum of 150 categories may be used to determine or assign areas of responsibilities to each user account.
- f. A minimum of 100 unique passwords shall be supported.
- g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
- h. Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.
- i. The system shall automatically generate a report of log-on/log-off and system activity for each user.
- j. The system shall have the ability to provide a Department of Defense (DoD) specific warning banner for applicable sites that warns the user they are accessing a restricted site.
- k. After successful login the last time and date that user name was previously logged in is shown on the screen.
- l. Each login attempt is recorded in the system Audit Log with the option to record the IP address of the PC that made the login.
- 2. Screen Manager
  - a. The system will allow a customized image on the login screen (e.g. organization name, logo).
  - b. User View navigations can be displayed as either a set of tabs or a drop down list.
  - c. Allows user preference for assigning of a background color for when an object is Out of Service which will enable the operator to quickly distinguish points that have been commanded to this state.
  - d. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
- 3. Historical trending and data collection
  - a. Each Network Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
    - 1) Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:
      - a) Defined time interval
      - b) Upon a change of value
  - b. Each Network Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

## 2.5 NETWORK CONTROL ENGINE (NCE)

- A. Network Control Engine (NCE)
  - 1. The Network Control Engine shall be a fully user-programmable, supervisory controller. The NCE shall monitor the network of equipment controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Engines.
  - 2. The NCE shall also be a fully user-programmable, equipment controller that includes a minimum of 28 I/O points.
  - 3. Automation Network – The NCE(s) shall reside on the automation network and shall support a subnet system controllers via an integral Control network connection.

4. Automation network temporary cellular connection – The BAS shall be provided with a temporary connection via a “master” control engine whereby the Automation network and connected “slave” engines can be accessed remotely before Owner’s IT network is operational. This project shall include at least one connected control engine.
  - a. The connected control engine shall be a standard catalog product of the BAS manufacturer. Non-standard or custom applications are not acceptable.
  - b. This connected control engine shall be panel mounted with a cellular modem, remote antenna and antenna cables, 5 port Ethernet switch, and a power supply with convenience outlet,
  - c. The “master” control engine shall communicate with a temporary Automation Data Server which can be used to remotely load graphics, generate and load database, program, commission and demonstrate the BAS.
  - d. A one-year cellular contract shall be included within this contract at no additional cost to the Owner. Multiple cellular services shall be made available to choose from to allow for best connection strength at the jobsite. The costs of the remote server shall be included within this contract at no additional cost to the Owner.
5. User Interface – Each Network Control Engine shall have the ability to deliver a web-based User Interface previously described. All computers connected physically or virtually to the automation network shall have access to the web-based user interface.
6. Processor – The NCE(s) shall be microprocessor-based with a minimum word size of 32 bits. The Network Control Engine shall be a multi-tasking, multi-user, and real-time digital control process. Standard operating systems shall be employed. NCE(s) size and capability shall be sufficient to fully meet the requirements of this Specification.
7. Memory – Each NCE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
8. Secure Boot – The NCE shall prevent malicious or unauthorized software applications from loading during the system startup process.
9. Background File Transfer – The NCE shall provide the capability to download a new image and database to a network engine while the engine is still running and controlling the building.
10. User Authentication – The NCE shall support local user authentication.
11. Password Security – Access to the Network Control Engines’ embedded user interface shall require a password of 8 to 50 characters including a minimum of one lower case letter, one upper case letter, one number, and one special character. An alarm shall be generated after three unsuccessful attempts within 15 minutes and the user shall be denied access until permission is renewed by a system administrator.
12. Network Security – Communication between the NCE and other system networked devices including additional Network Engines, Application and Data Servers, Open Data Servers (BACnet listed OWS), and user interface clients shall be encrypted and support HTTPS with Transport Level Security (TLS) Version 1.2. Self-signed certificates are to be provided with the option of configuring trusted certificates. Engines shall also be equipped to optionally support FIPS 140-2 Federal Government encryption standard.
13. Hardware Real Time Clock – The Network Control Engine shall include an integrated, hardware-based, real-time clock, with a supercapacitor to maintain time for a minimum of 72 hours during a power loss. Controllers using a battery to maintain time during a power loss shall not be acceptable.
14. Diagnostics – The NCE(s) shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The NCE(s) shall provide both local and remote annunciation of any detected component failures or repeated failures to establish communication.
15. Power Failure – In the event of the loss of normal power, the NCE(s) shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

- a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
  - b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
16. Certification – The NCE(s) shall meet and be listed to the UL 916 Standard for Energy Management Equipment and be FCC Compliant to CFR47, Part 15, Subpart B, Class A.
17. Device Integration – The NCE(s) shall support integrating and supervising networked devices using the following communication protocols on the device/controller network:
  - a. The NCE (s) shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135 on the controller network.
    - 1) The NCE (s) shall support Remote Field Bus integration via a BACnet IP to MS/TP router.
    - 2) The NCE (s) shall be tested and BTL listed/certified as a BACnet Building Controller (B-BC).
    - 3) A BACnet Protocol Implementation Conformance Statement shall be provided for the NCE(s).
  - b. The NCE(s) shall optionally support integration of networked devices using the following networking protocols:
    - 1) BACnet
    - 2) Johnson Controls N2 or third party N2 Open devices.
    - 3) LonTalk
    - 4) MODBUS RTU
    - 5) MODBUS TCP
    - 6) KNX
    - 7) M-Bus
    - 8) OPC UA
18. The NCE shall employ a finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
19. The NCE shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only, shall not be acceptable.
20. The NCE shall support the following types of inputs and outputs:
  - a. Universal Inputs – shall be configured to monitor any of the following for Analog inputs: Voltage Mode, Current Mode, Resistive Mode. For Binary Inputs: Dry Contact Maintained Mode, Pulse Counter Mode
  - b. Analog Outputs – shall be configured to output either of the following: Voltage Mode, Current Mode
  - c. Binary Outputs – shall output the following: 24VAC Triac
  - d. Configurable Outputs – shall be configured to output either of the following:
    - 1) Analog Output Voltage Mode
    - 2) Binary Output 24 VAC Triac Mode
  - e. The NCE shall have the ability to monitor and control a network of sensors and actuators over a Sensor Actuator (SA) Bus dedicated to the controller. This bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135 supporting no less than 9 devices with a maximum distance of 1,200 Ft. between the NCE and the furthest connected device.
21. The NCE shall provide removable, labeled, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.
22. The NCE shall include the following multi-color, flashing LEDs to indicate important operating conditions and status

23. Communications Ports – The NCE(s) shall provide the following ports for connecting networkable devices:
  - a. Two (2) USB ports
  - b. One (1) RS-485 port
  - c. Two (2) Ethernet ports
24. The NCE shall support an integrated user interface featuring a display and keypad in lieu of on-board HOA switches for output overrides.
  - a. The integrated user interface shall allow viewing and monitoring points, alarms, and trends.
  - b. The integrated user interface shall allow viewing and changing setpoints, modes of operation, and parameters.
  - c. The integrated user interface shall provide password protection with user-adjustable password timeout.
  - d. The information presented by the integrated user interface shall be organized into folders for easy navigation.
  - e. The integrated user interface shall support textual descriptions in English for each point.
  - f. The display shall be, at minimum, a 2.4-inch, color display with 320x240 resolution.
  - g. The display shall support adjustable contrast and brightness.
  - h. The keypad shall include no more than seven (7) keys.
25. The NCE shall support up to 50 supervised devices across all supported integrations.

## 2.6 DDC EQUIPMENT CONTROLLERS

### A. General Purpose Application Controller (GPAC)

1. The General Purpose Application Controller (GPAC) shall be a fully programmable, digital controller that communicates via the BACnet MS/TP protocol over the FC Bus.
  - a. The GPAC shall support BACnet Standard ANSI/ASHRAE 135.
    - 1) The GPAC shall be BTL listed/certified.
    - 2) The GPAC shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
    - 3) A BACnet Protocol Implementation Conformance Statement shall be provided for the GPAC.
2. The GPAC shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
3. GPAC shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
4. The GPAC shall be assembled in a plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.
5. The GPAC shall include an integral real-time clock and support time-based tasks which enables these field controllers to monitor and control schedules, calendars, alarms, and trends.
6. The GPAC can continue time-based monitoring when offline for extended periods of time from a network.
7. The GPAC can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.
8. The GPAC shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.

9. The GPAC shall have the ability to transfer and apply firmware files to all SA Bus devices (EOIM, IOM, and networked zone sensors) connected to it.
10. The GPAC shall include removable and labeled screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.
11. The GPAC shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.
  - a. Inputs – 24-bit analog-to-digital converter
  - b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
12. The GPAC shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:
  - a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
  - b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
  - c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
  - d. Binary Outputs – 24 VAC Triac
  - e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
13. The GPAC shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.
14. The GPAC shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
15. The GPAC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over a MS/TP Bus.
16. The GPAC shall support a Local Controller Display as a remote device communicating over the SA Bus.
  - a. The Display shall use a BACnet Standard SSPC-135 MS/TP protocol.
  - b. The Display shall allow the user to view monitored points without logging into the system.
  - c. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
  - d. The Display shall provide password protection with user adjustable password timeout.
  - e. The Display shall be menu driven with separate paths for:
    - 1) Input/Output
    - 2) Parameter/Setpoint
    - 3) Overrides
  - f. The Display shall use easy-to-read English text messages.
  - g. The Display shall allow the user to select the points to be shown and in what order.
  - h. The Display shall support a back lit LCD with adjustable contrast and brightness and automatic backlight brightening during user interaction.
  - i. The Display shall have a keypad.
  - j. The Display shall be panel mountable.

## 2.7 FIELD DEVICES

### A. Expansion Input/Output Module (EIOM)

1. The EIOM provides additional input and output interfaces for use in digital controllers.
2. The EIOM shall communicate with controllers over the FC Bus or the SA Bus.
3. The EIOM shall support BACnet Standard ANSI/ASHRAE 135.
  - a. The EIOM shall be BTL listed/certified and carry the BTL Label.
  - b. The EIOM shall be tested and certified as a BACnet Smart Actuator (B-SA).
  - c. A BACnet Protocol Implementation Conformance Statement shall be provided for the IOM.

4. The EIOM shall include removable screw terminal blocks for all I/O, SA/FC bus communication, and power wiring connections.
  5. The EIOM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
  6. The IOM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution:
    - a. Inputs – 24-bit analog-to-digital converter
    - b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
  7. The EIOM shall support the following types of inputs and outputs:
    - a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
    - b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
    - c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
    - d. Binary Outputs – 24 VAC Triac
    - e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
  8. The EIOM shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.
- B. Networked Thermostat (TEC)
1. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
    - a. Two-line, 8 character backlit display
    - b. LED indicators for Fan, Heat, and Cool status
    - c. Five (5) User Interface Keys
      - 1) Mode
      - 2) Fan
      - 3) Override
      - 4) Degrees C/F
      - 5) Up/Down
  2. The Networked Thermostats shall provide the flexibility to support the following inputs:
    - a. Integral Indoor Air Temperature Sensor
    - b. Duct Mount Air Temperature Sensor
    - c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator.
    - d. Two configurable binary inputs
  3. The Networked Thermostats shall provide the flexibility to support the following outputs:
    - a. Three Speed Fan Control
    - b. On/Off Control
    - c. Floating Control
    - d. Proportional (0 to 10V) Control
- C. Network Sensors (NS)
1. The Network Sensors (NS) shall have the ability to monitor the following variables all within a single wall-mounted enclosure (no exceptions) as required by the systems sequence of operations:
    - a. Zone temperature
    - b. Zone humidity
    - c. Zone carbon dioxide
    - d. Zone set point
  2. The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135.
  3. The NS shall be BTL listed/certified and carry the BTL Label.
    - a. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
  4. The Network Zone Temperature Sensors shall include the following items:

- a. A backlit LCD to indicate the temperature, humidity and setpoint
  - b. An LED to indicate the status of the Override feature
  - c. A button to toggle the temperature display between Fahrenheit and Celsius
  - d. A button to program the display for temperature or humidity
  - e. A button to initiate a timed override command
  - f. Available in either surface mount, wall mount, or flush mount
  - g. Available with either screw terminals or phone jack
- D. VAV Box Controller (VBC)
1. The VAV Box Controller (VBC) shall provide both standalone and networked DDC of pressure independent, VAV terminal units.
  2. The VBC controller shall be a fully programmable, digital controller that communicates via BACnet MS/TP protocol over the FC Bus.
    - a. The VBC shall support BACnet Standard ANSI/ASHRAE 135.
      - 1) The VBC shall be BTL listed/certified.
      - 2) The VBC shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
      - 3) A BACnet Protocol Implementation Conformance Statement shall be provided for the VBC.
  3. The VBC shall include 14 preloaded single duct VAV box control applications to allow the VBC to be made fully operational without the need to create a custom program.
  4. The VBC shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
  5. The VBC shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
  6. The VBC shall be assembled in a plenum-rated plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.
    - a. The VBC shall include an integral real-time clock and support time-based tasks which enables these equipment controllers to monitor and control schedules, calendars, alarms, and trends
  7. The VBC can continue time-based monitoring when offline for extended periods of time from a network.
  8. The VBC shall include an integral differential pressure transducer and damper actuator. An additional configuration option shall be available that also includes an integral potentiometer for actual damper position feedback. All components shall be connected and mounted as a single assembly, removable as one piece.
  9. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 60 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
  10. The VBC shall determine airflow by a state-of-the-art, digital, non-flow pressure sensor that supports automatic correction for polarity on high- and low-pressure DP tube connections to eliminate high- and low-pressure connection mistakes.
  11. The VBC shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
  12. The VBC can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.
  13. The VBC shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.

14. The VBC shall have the ability to transfer and apply firmware files to all SA Bus devices (EOIM, IOM, and Networked zone sensors) connected to it.
15. The VBC shall include removable screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.
16. The VBC shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.
  - a. Inputs – 24-bit analog-to-digital converter
  - b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
17. The VBC shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:
  - a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
  - b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
  - c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
  - d. Binary Outputs – 24 VAC Triac
  - e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
18. The VBC shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.
19. The VBC shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
20. The VBC shall have the capability to execute VAV box control sequences involving direct wired I/O points as well as input and output devices communicating over the SA or FC buses.
21. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
22. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
23. The controller shall provide the ability to download and upload VAV box control application configuration files, both locally and via the FC Bus. Controllers shall be able to be loaded individually or as a group.
24. Control setpoint changes initiated over the network shall be written to VBC non-volatile memory.
25. The VBC controller firmware shall be flash-upgradeable remotely via the FC bus.
26. The VBC controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
27. The VBC controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
28. The VBC controller shall have on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VBC shall calculate Exponentially Weighted Moving Averages (EWMA) for each of the following metrics, which shall be available to the end user for efficient management of the VAV terminals.
29. The controller shall detect system error conditions to assist in managing the VAV zones.
30. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VBC would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
31. The VBC controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality) and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.

32. The VBC controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

E. System Tools

1. One software copy of each system tool shall be provided with the BAS.
2. System Configuration Tool
  - a. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Engine.
  - b. The configuration tool shall provide an archive database for the configuration and application data.
  - c. The configuration tool shall provide a site discovery feature to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
    - 1) BACnet Devices
    - 2) LonWorks devices
    - 3) Johnson Controls N2 Bus devices
  - d. A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
  - e. Provide Johnson Controls SCT or approved equal.
3. Controller Configuration Tool (CCT)
  - a. As part of the single software tool environment including system and controller elements, the Controller Configuration Tool (CCT) shall be used to configure, simulate and commission equipment controllers and NCE controllers.
  - b. The CCT shall operate in distinct modes to facilitate efficiency at various steps in the steps leading to project completion as well as future upgrades and maintenance
  - c. The configuration tool shall be capable of programming the Equipment Controllers.
    - 1) The configuration tool shall provide the capability to configure, simulate, and commission the Equipment Controllers.
    - 2) The configuration tool shall allow the equipment controllers to be run in Simulation Mode to verify the applications.
    - 3) The configuration tool shall contain a library of standard applications to be used for configuration.
  - d. The CCT shall provide multiple options for downloading files to the controllers including direct wired, wireless and Ethernet pass thru as dictated by controller type and location.

F. Airflow Control Sound Specifications:

1. Unless otherwise specified the airflow control device shall not exceed the sound power levels in Table 1, Table 2, or Table 3.
2. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.
3. All proposed airflow control devices shall include discharge, exhaust, and radiated sound power level performance.
4. Table 1. Exhaust Airflow Control Device Sound Power Level (Airborne).

	Exhaust Sound Power Level in dB (re: 10 <sup>-12</sup> watts)					
Octave Band Number	2	3	4	5	6	7

Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
<b>1000-50 cfm Device</b>						
800 cfm @ 0.6" wc	63	55	52	54	50	49
200 cfm @ 0.6" wc	46	42	38	37	32	25
800 cfm @ 3.0" wc	73	70	64	66	65	60
200 cfm @ 3.0" wc	51	52	51	50	52	51
<b>1500-100 cfm Device</b>						
1200 cfm @ 0.6" wc	65	58	53	56	52	52
400 cfm @ 0.6" wc	50	45	38	39	37	31
1200 cfm @ 3.0" wc	72	70	62	65	64	60
400 cfm @ 3.0" wc	55	57	55	53	56	55
<b>3000-200 cfm Device</b>						
2400 cfm @ 0.6" wc	63	56	55	58	54	55
800 cfm @ 0.6" wc	51	45	41	42	39	34
2400 cfm @ 3.0" wc	74	71	65	69	67	63
800 cfm @ 3.0" wc	58	58	56	56	59	58

5. Table 2. Supply Airflow Control Device Sound Power Level (Airborne)

	Discharge Sound Power Level in dB (re: 10 <sup>-12</sup> watts)					
Octave Band Number	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
<b>1000-50 cfm Device</b>						
800 cfm @ 0.6" wc	62	57	54	58	54	51
200 cfm @ 0.6" wc	45	46	42	44	40	34
800 cfm @ 3.0" wc	72	71	67	75	72	68
200 cfm @ 3.0" wc	53	56	54	58	56	54
<b>1500-100 cfm Device</b>						
1200 cfm @ 0.6" wc	63	59	55	60	54	53
400 cfm @ 0.6" wc	53	49	44	49	45	39
1200 cfm @ 3.0" wc	72	73	69	77	72	68

400 cfm @ 3.0" wc	58	63	61	63	60	57
<b>3000-200 cfm Device</b>						
2400 cfm @ 0.6" wc	64	60	58	63	56	56
800 cfm @ 0.6" wc	52	48	47	52	46	41
2400 cfm @ 3.0" wc	75	75	72	78	73	70
800 cfm @ 3.0" wc	59	62	62	66	62	60

6. Table 3. Supply Airflow Control Device Sound Power Level (Radiated)

	Radiated Sound Power Level in dB (re: 10 <sup>-12</sup> watts)					
Octave Band Number	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
<b>1000-50 cfm Device</b>						
800 cfm @ 0.6" wc	44	41	45	41	36	34
200 cfm @ 0.6" wc	33	28	31	29	26	20
800 cfm @ 3.0" wc	53	53	56	57	55	53
200 cfm @ 3.0" wc	41	38	41	39	39	37
<b>1500-100 cfm Device</b>						
1200 cfm @ 0.6" wc	47	53	40	42	38	36
400 cfm @ 0.6" wc	35	39	31	34	33	26
1200 cfm @ 3.0" wc	52	60	54	60	59	53
400 cfm @ 3.0" wc	42	44	43	46	46	42
<b>3000-200 cfm Device</b>						
2400 cfm @ 0.6" wc	58	56	45	47	43	42
800 cfm @ 0.6" wc	45	43	36	39	37	29
2400 cfm @ 3.0" wc	69	68	60	65	63	57
800 cfm @ 3.0" wc	54	53	48	51	50	48

G. Occupancy Sensor

- Occupancy sensors shall use a combination Passive Infrared (PIR) and Microwave technology with continuous monitoring and built-in diagnostics. Ceiling mounted units shall have 360 deg field-of-view.
- Basis of design: IntelliSense DT-6360STC

H. Control valves: As specified elsewhere under this Section.

- I. Sensors and Binary Devices: As specified elsewhere under this Section.
- J. Miscellaneous control devices: All other control devices not specifically identified under Laboratory Control System shall meet specific item requirements listed elsewhere under this Section.
- K. Building Automation System Interface
  - 1. All points shall be provided to and from the BAS.
  - 2. Information shall be communicated by seamless LAN connections.

## 2.8 INPUT DEVICES

- A. General Requirements
  - 1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
- B. Temperature Sensors
  - 1. General Requirements:
    - a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
    - b. The temperature sensor shall be of the resistance type and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
    - c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
  - 2. Room Temperature Sensors
    - a. Room sensors shall be constructed for either surface or wall box mounting.
    - b. Room sensors shall have the following options when specified:
      - 1) Set point reset providing a +3 degree (adjustable) range.
      - 2) Individual heating/cooling set point slide switches.
      - 3) A momentary override request push button for activation of after-hours operation.
    - c. Provide digital display of sensed temperature.
  - 3. Thermo wells
    - a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
    - b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
    - c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
    - d. Thermo wells shall be constructed of 316 stainless steel.
  - 4. Outside Air Sensors
    - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
    - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
    - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
  - 5. Duct Mount Sensors
    - a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
    - b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

- c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
  - 6. Averaging Sensors
    - a. For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
    - b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
    - c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
- C. Humidity Sensors
  - 1. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
  - 2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
  - 3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
  - 4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealite fittings and stainless steel bushings.
  - 5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
  - 6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
- D. Carbon Dioxide Sensors
  - 1. Duct Mounted
    - a. Sensor shall be remote-mounted diffusion-aspirated, single-beam dual-wavelength sensor type with Infrared (IR) source, sample cell, tunable-interference filter, and IR detector.
    - b. Sensing cell shall be provided with thirty (30) inch cable for duct mounting.
    - c. Sensor shall produce linear analog 0-1 Volt DC, 4-20 MA, and binary adjustable switch point form C outputs.
    - d. Range shall be 0-2000 parts per million with accuracy of two (2) percent.
    - e. Sensor shall be mounted in weather tight enclosure with forty-one (41) degree Fahrenheit to 104 degree Fahrenheit operating temperature.
    - f. Sensor shall be capable of maintaining calibration within 2% for a one year period of operation.
  - 2. Wall Mounted
    - a. Sensor shall be wall-mounted diffusion-aspirated, single-beam dual-wavelength sensor type with Infrared (IR) source, sample cell, tunable-interference filter, and IR detector. .
    - b. Sensing cell shall be provided with thirty (30) inch cable for duct mounting.
    - c. Sensor shall produce linear analog 0-1 Volt DC, 4-20 MA, and binary adjustable switch point form C outputs.
    - d. Range shall be 0-2000 parts per million with accuracy of two (2) percent.
    - e. Sensor shall be mounted in weather tight enclosure with forty-one (41) degree Fahrenheit to 104 degree Fahrenheit operating temperature.
    - f. Sensor shall be capable of maintaining calibration within 2% for a one year period of operation.
- E. Differential Pressure Transmitters

1. General Air and Water Pressure Transmitter Requirements:
  - a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
  - b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
  - c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
  - d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
2. Low Differential Water Pressure Applications (0" - 20" w.c.)
  - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.
  - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
  - c. .01-20" w.c. input differential pressure range.
  - d. 4-20 mA output.
  - e. Maintain accuracy up to 20 to 1 ratio turndown.
  - f. Reference Accuracy: +0.2% of full span.
3. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
  - a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
    - 1) Differential pressure range 10" w.c. to 300 PSI.
    - 2) Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
  - b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
4. Building Differential Air Pressure Applications (-1" to +1" w.c.)
  - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
  - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
    - 1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
    - 2) 4-20 mA output.
    - 3) Maintain accuracy up to 20 to 1 ratio turndown.
    - 4) Reference Accuracy: +0.2% of full span.
5. Low Differential Air Pressure Applications (0" to 5" w.c.)
  - a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
  - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
    - 1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
    - 2) 4-20 mA output.

- 3) Maintain accuracy up to 20 to 1 ratio turndown.
    - 4) Reference Accuracy: +0.2% of full span.
  6. Medium Differential Air Pressure Applications (5" to 21" w.c.)
    - a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
      - 1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
      - 2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
      - 3) Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).
    - b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
- F. Air Flow Monitoring - Fan Inlet Airflow Measuring Station (AFMS)
  1. Subject to compliance with all requirements of this section, provide EBTRON, Inc. Model GTx108-F (basis of design) or approved equal.
  2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
    - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
    - b. Vortex shedding airflow measurement devices, pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices are not acceptable.
  3. General
    - a. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature of each fan at each measurement location.
    - b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
      - 1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
    - c. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.
      - 1) Actual airflow rate calculations shall have the capability of being field adjusted by the transmitter for altitudes other than sea level.
    - d. Temperature output shall be field configurable to provide either the velocity-weighted duct average temperature or simple arithmetic average temperature.
  4. Sensor Probes
    - a. Each sensor probe shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
    - b. Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
    - c. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure.
      - 1) Plenum rated PVC jacket cables are not acceptable.
    - d. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
    - e. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.

- f. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.
    - 1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
  - g. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
  - h. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
  - i. The number of independent sensor nodes provided shall be as follows:
    - 1) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet
    - 2) Fan Arrays (2 to 4 fans):
      - a) 2 probes x 1 sensor node per probe in each fan inlet
    - 3) Fan Arrays (5 to 8 fans): 1 probe x 1 sensor node per probe in each fan inlet.
- 5. Transmitter
  - a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
  - b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
  - c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
  - d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
  - e. All receptacle plug pins shall be gold plated.
  - f. The transmitter shall be capable of determining the average airflow rate and temperature of each fan.
    - 1) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
  - g. The transmitter shall have startup firmware to facilitate setup of multiple fans and fan areas.
  - h. The transmitter shall be capable of providing a high and/or low airflow alarm.
  - i. The transmitter shall be capable of providing individual fan alarming on fan array configurations.
  - j. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
  - k. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
    - 1) The total airflow rate, temperature, airflow alarm, individual fan alarm and system status alarm shall be visible on the display.
  - l. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and either:
    - 1) one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection; or
    - 2) one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection. Note: LonWorks capable models shall be provided without analog outputs.
  - m. Analog signal capability shall include two output terminals: the first, shall provide the total airflow rate; while the second output shall be field configurable to provide one of the following:
    - 1) temperature
    - 2) airflow alarm
    - 3) individual fan alarm; or
    - 4) system status alarm
  - n. Network communications shall provide: the total airflow rate, average temperature, individual fan airflow rates, individual fan temperatures, airflow alarm, individual fan

- alarm, system status alarm, individual sensor node airflow rates, individual sensor node temperatures and fan inlet area.
  - o. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
  - p. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.
  - 6. Performance
    - a. Each sensing node shall have an airflow accuracy of  $\pm 2\%$  of reading over an operating range of 0 to 10,000 FPM.
      - 1) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
        - a) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
    - b. Each sensing node shall have a temperature accuracy of  $\pm 0.15^\circ \text{F}$  over an operating range of  $-20^\circ \text{F}$  to  $160^\circ \text{F}$ .
  - 7. Install in accordance with manufacturer’s placement and installation guidelines.
- G. Air Flow Monitoring Station – Duct Mounted
- 1. Subject to compliance with all requirements of this section, provide Ebtron, Inc. Advantage IV GTx116e-P+ (basis of design) or approved equal.
  - 2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
    - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
  - 3. General
    - a. Provide one Air Flow Measuring Station (AFMS) for each measurement location provided on the plans, schedules and/or control diagrams to determine the average outdoor airflow rate at each duct measurement location.
    - b. Each AFMS shall be provided with a microprocessor-based transmitter and one or more sensor probes.
      - 1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
    - c. Airflow measurement shall provide independent, arithmetic average.
    - d. Temperature output shall provide the independent, velocity-weighted duct average temperature.
  - 4. Individual Sensing Nodes
    - a. Sensing Node Sensors
      - 1) Self-heated sensor: Precision, hermetically sealed, bead-in-glass
      - 2) thermistor probe
      - 3) Temperature sensor: Precision, hermetically sealed, bead-in-glass
      - 4) thermistor probe
    - b. Sensing Node Housing
      - 1) Material: Glass-filled Polypropylene (Kynar® with /SS option)
      - 2) Sensor Potting Materials: Waterproof marine epoxy
    - c. Sensing Node Internal Wiring
      - 1) Type: Kynar® coated copper
    - d. Airflow Measurement

- 1) Accuracy:  $\pm 2\%$  of reading to NIST-traceable airflow standards (includes transmitter uncertainty)
  - 2) Calibrated Range: 0 to 5,000 fpm
  - 3) Calibration Points: 16
- e. Temperature Measurement
  - 1) Accuracy:  $\pm 0.15^\circ\text{F}$  to NIST-traceable temperature standards (includes transmitter uncertainty)
  - 2) Calibrated Range: -20 to  $160^\circ\text{F}$
  - 3) Calibration Points: 3
5. Sensor Probe Assembly
  - a. Tube
    - 1) Material: Gold anodized 6063 aluminum
  - b. Mounting Brackets
    - 1) Material: 304 stainless steel
  - c. Mounting Options & Size Limits
    - 1) Insertion: 6 to 191 in.
    - 2) Stand-off: 6 to 190 in.
    - 3) Internal: 8 to 194 in.
  - d. Probe to Transmitter Cables
    - 1) Type: FEP jacket, plenum rated CMP/CL2P, UL/cUL listed, -67 to  $302^\circ\text{F}$ , UV tolerant
    - 2) Connecting Plug: 13/16" nominal diameter with gold plated connector pins
6. Transmitter
  - a. Power Requirement: 24 VAC (22.8 to 26.4 under load) @20V-A max.
  - b. Connector Receptacle Pins and PCB Connections: Gold-plated receptacle pins, PCB interconnects, PCB edge fingers, and test points
  - c. User Interface: 2 line x16-character backlit LCD display and 4 button interface
  - d. BAS Connectivity
    - 1) Transmitter: Three field selectable (0-5/0-10 VDC or 4-20mA), scalable and isolated analog output signals (AO1=airflow, AO2=temperature or alarm, AO3=Not Used).
    - 2) One additional isolated Ethernet (BACnet Ethernet/IP) network connection - Individual sensor node airflow rates and temperatures are available via the network.
  - e. Airflow Alarm
    - 1) Type: Low and/or high user defined setpoint alarm
    - 2) Tolerance: User defined % of setpoint
    - 3) Delay: User defined
    - 4) Zero Disable: Alarm can be disabled when the airflow rate falls below the low limit cutoff value (unoccupied periods)
    - 5) Reset Method: Manual or automatic
    - 6) Visual Indication: LCD display
    - 7) Analog Signal Indication: On AO2 assignment
  - f. System Status Alarm
    - 1) Type: Sensor diagnostic system trouble indication

- 2) Visual Indication: LCD display
    - 3) Analog Signal Indication: On AO2 assignment
  7. Install in accordance with manufacturer's placement and installation guidelines.
- H. Air Flow Monitoring – Combination Outdoor Airflow Measuring and Control Damper
1. Basis-of-Design Product: Provide TAMCO/EBTRON AIR-IQ or comparable product by one of the following.
    - a. TAMCO/EBTRON
    - b. Greenheck
    - c. Ruskin
  2. Type: Factory assembled, damper mounted electronic thermal dispersion airflow and temperature measurement device.
  3. Mounting: The suitable for horizontal or vertical airflow applications, as required.
  4. Performance:
    - a. Leakage: Class 1A.
    - b. Operating Temperature Limits: -20°F to 160°F.
    - c. Temperature Accuracy:  $\pm 0.14^{\circ}\text{F}$  over the entire operating temperature range.
    - d. Airflow Accuracy:  $\pm 2\%$  of reading.
    - e. Airflow Rates: 0 to 5,000 FPM.
  5. Damper and Sleeve:
    - a. Frame: Galvanized steel 5" x 1" structural hat channel, minimum 16 gauge.
    - b. Blades: Heavy gauge extruded aluminum, airfoil shape.
    - c. Blade Orientation: Horizontal.
    - d. Blade Operation: Opposed blade or parallel.
    - e. Seals:
      - 1) Blade Edge: Silicon or extruded EPDM, mechanically fastened to each blade.
      - 2) Frame: Extruded silicon.
    - f. Linkage: Concealed in frame out of the airstream, plated steel material.
    - g. Axles: Minimum  $\frac{1}{2}$  inch dia. stainless steel or aluminum. Removable control shaft shall extend 6" beyond the damper frame.
    - h. Bearings: 304 stainless steel or celcon acetal copolymer.
    - i. Sleeve: 18-inch, minimum 20-gauge sleeve with air straightener.
  6. Airflow/Temperature Measurement Devices
    - a. Probes: Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
    - b. Sensor Node: Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
    - c. Sensor Density Requirements: Number of individual sensor nodes provided for each damper location shall be detailed in published documentation by the manufacturer.
    - d. Wiring: All internal wiring between thermistors and probe connecting cables shall be Kynar jacketed.
      - 1) Manufacturer shall provide UL listed, FEP jacketed, plenum rated cable(s) between sensor probes and the remote transmitter.
  7. Transmitter:
    - a. Supplied by the same manufacturer as the measuring station.
    - b. Input power shall be 24VAC/24VDC. Include over-voltage and over-current protection, and ensure continuous operation following power failures and/or brown-outs.
    - c. Analog output shall be field configurable as linear 0-5 VDC, 0-10 VDC or 4-20mA signals.
    - d. Two isolated and fused analog output signals and one RS-485 network connection

- 1) One analog output signal shall provide the average airflow rate.
- 2) One analog output signal shall be field configurable to output the average temperature, the velocity weighted temperature or a binary airflow alarm.
- 3) The RS-485 network connection shall be field configurable as BACnet MS/TP.
- e. The RS-485 connection shall transmit the average airflow rate, average temperature, individual airflow rates of each sensor node, and individual temperatures of each sensor node and system status.
- f. High visibility backlit LCD for display of either the averaged or individual sensor airflow and temperature measurements, in user selectable units of measure.

Specify the following air flow monitor for installation in the OA hood of small packaged RTU's. Hood size can only be a maximum of 8 SF.

I. Air Flow Monitoring – Outdoor Air Hood

1. Provide airflow temperature measurement device for installation in the outdoor air hood (with adjustable standoff) of rooftop packaged air handling unit. Provide where indicated on the drawings, upstream of the outdoor damper.
2. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Each transmitter shall operate on 24VAC.
3. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and averaged by the transmitter prior to output.
4. General
  - a. Probe and Sensor Node Configurations
    - 1) 1 probe x 1 sensor node
    - 2) 2 probes x 1 sensor node/probe
  - b. Installed Airflow Accuracy
    - 1) In Openings Less or Equal to 8 sq.ft.:  $\pm(3\% \text{ to } 15\%)$ , typical.
    - 2) In Openings Greater Than 8 sq.ft.: Not recommended.
  - c. Sensor Node Averaging Method
    - 1) Airflow: Independent (arithmetic average on 2 sensor configurations installed at a single measurement location).
    - 2) Temperature: Independent, velocity weighted average on 2 sensor configurations installed at a single measurement location.
  - d. Listings and Compliance
    - 1) UL: 60730-1, 60730-2-9; CAN E60730-1, E60730-2-9 (EF-A2000-U Only).
    - 2) FCC: This device complies with Part 15 of the FCC rules.
    - 3) RoHS: This device is RoHS2 compliant.
  - e. Environmental Limits
    - 1) Temperature:
      - a) Probes 0 to 2,000 fpm: -20 to 160 °F.
      - b) Probes 0 to 3,000 fpm: 0 to 160 °F .
      - c) Transmitter: -20 to 120 °F.
    - 2) Humidity: (non-condensing).
      - a) Probes: 0 to 100%.
      - b) Transmitter: 5 to 95%.
5. Individual Sensing Nodes
  - a. Sensing Node Sensors
    - 1) Self-heated sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.
    - 2) Temperature sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.
  - b. Sensing Node Housing
    - 1) Material: Glass-filled Polypropylene.
    - 2) Sensor Potting Materials: Waterproof marine epoxy.

- c. Sensing Node Internal Wiring
  - 1) Type: Kynar® coated copper.
- d. Airflow Measurement
  - 1) Accuracy:  $\pm 3\%$  of reading (typical), 4% max. to NIST-traceable airflow standards (includes transmitter uncertainty).
  - 2) Calibrated Range: 0 to 3,000 fpm.
  - 3) Calibration Points: 7.
- e. Temperature Measurement
  - 1) Accuracy:  $\pm 0.15$  °F to NIST-traceable temperature standards (includes transmitter uncertainty).
- 6. Sensor Probe Assembly
  - a. Tube
    - 1) Material: Mill finish 6063 aluminum.
  - b. Mounting Brackets
    - 1) Material: 304 stainless steel.
  - c. Mounting Type & Overall Probe Length
    - 1) Insertion: 6, 8 or 16 in. (adjustable).
    - 2) Stand-off: 6, 8 or 16 in. (adjustable).
  - d. Probe to Transmitter Cables
    - 1) Type: FEP jacket, plenum rated CMP/CL2P, UL/cUL listed, -67 to 302 °F, UV tolerant.
    - 2) Standard Lengths: 10, 25 and 50 ft.
    - 3) Connecting Plug: 0.60" nominal diameter.
- 7. Transmitter
  - a. Power Requirement: 24 VAC (22.8 to 26.4 under load) @8V-A.
  - b. User Interface: 16-character LCD display and 4 button interface.
  - c. BAS Connectivity:
    - 1) EF-N2000 Transmitter: One field selectable (BACnet MS/TP or Modbus RTU) and non-isolated RS-485 network connection. Individual sensor node airflow rates and temperatures shall be available via the network (provide individual 24 VAC transformers for each EF-N2000 transmitter for applications requiring isolated RS-485).
  - d. Relay
    - 1) Type: Dry Contact w/ onboard jumper to drive a remote LED (R1=alarm).
    - 2) Status: N.O. or N.C. via user setup configuration.
    - 3) Rating: 30 VDC or 24 VAC @ 3 amp. max.
  - e. Airflow Alarm
    - 1) Type: Low and/or high user defined setpoint alarm.
    - 2) Tolerance: User defined % of setpoint.
    - 3) Delay: User defined.
    - 4) Zero Disable: Alarm can be disabled when the airflow rate falls below the low limit cutoff value (unoccupied periods).
    - 5) Reset Method: Manual or automatic.
    - 6) Visual Indication: Yes, LCD display.
    - 7) Network Indication: Yes (EF-N2000 only).
    - 8) Analog Signal Indication: Yes, on AO2 assignment (EF-A2000 only).
    - 9) Contact Closure Relay: Yes, on R1 assignment.
  - f. System Status Alarm
    - 1) Type: Sensor diagnostic system trouble indication.
    - 2) Visual Indication: Yes, LCD display.
    - 3) Network Indication: Yes (EF-N2000 only).
    - 4) Analog Signal Indication: Yes, on AO2 assignment (EF-A2000 only).
    - 5) Contact Closure Relay: Yes, on R1 assignment.
- 8. Install in accordance with manufacturer's placement and installation guidelines.
- 9. Basis of Design: Ebtron EB-Flow II EF-x2000-U

J. Water Flow Meters

1. Insertion Turbine Flowmeters:

- a. Basis-of-Design Product: Subject to compliance with requirements, provide ONICON Model F-1100 or comparable product by one of the following:
  - 1) ABB
  - 2) Dynasonics
  - 3) EMCO Flow Systems
  - 4) ERDCO Engineering Corp
  - 5) Hoffer Flow Controls, Inc
  - 6) ONICON Incorporated
- b. Description: Flowmeter with sensor and indicator.
- c. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
- d. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute.
  - 1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for water.
  - 2) Construction: Electroless nickel plated brass or stainless-steel body, with plastic turbine or impeller.
  - 3) Electronics Enclosure: Weathertight aluminum enclosure
  - 4) Minimum Pressure Rating: 200 psig.
  - 5) Minimum Temperature Rating: 180 deg F.
- e. Accuracy: Plus or minus 1 percent.
- f. Pressure Drop: Less than 1 PSI at 20 ft/s in 1½" pipe, decreasing in larger pipes and lower velocities.
- g. Display: Shows rate of flow, with register to indicate total volume in gallons.
- h. Output Signals Provided: Frequency Output 0 – 15 V peak pulse.
- i. Operating Instructions: Include complete instructions with each flowmeter.

K. Power Monitoring Devices

1. Current Measurement (Amps)

- a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
- b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.
  - 1) Operating frequency – 50 - 400 Hz.
  - 2) Insulation – 0.6 Kv class 10Kv BIL.
  - 3) UL recognized.
  - 4) Five amp secondary.
  - 5) Select current ration as appropriate for application.

2. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

- a. 6X input over amp rating for AC inrushes of up to 120 amps.
- b. Manufactured to UL 1244.
- c. Accuracy: +.5%, Ripple +1%.
- d. Minimum load resistance 30kOhm.
- e. Input 0-20 Amps.
- f. Output 4-20 mA.
- g. Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

L. Power and Energy Meters:

1. Power meters shall be furnished by BAS contractor, installed and wired by the electrical contractor. Communication trunk from the BAS and integration with the BAS shall be provided by the BAS contractor. Power meter(s) shall be compatible with the Building Automation System (BAS) provided under Division 23. Refer to Electrical
2. The power meter shall be fully electronic with multi-line backlit LCD display showing measured parameters as well as alarm functions and pulse output.
3. The power meter shall perform the following measurements:
  - a. Accumulated Real Energy (kWh) for each phase and total of all phases
  - b. Accumulated Reactive Energy (kVARh) and Apparent Energy (kVAh) totals for all phases
  - c. Net Present Demand for Real (kW), Reactive (kVAR) and Apparent (kVA) Power over a user-specified interval (block or sliding window)
  - d. Maximum (Peak) Real (kW), Reactive (kVAR) and Apparent (kVA) Demand Intervals
  - e. Instantaneous Real (kW), Reactive (kVAR) and Apparent Power (kVA), by phase and in total
  - f. Current (amps) for each phase and average of all phases
  - g. Phase-to-phase voltage for each phase and average of all phase pairs
  - h. Phase-to-neutral voltage for each phase pair and average of all phases
  - i. Power factor for each phase and average of all phases
  - j. AC frequency
4. The power meter shall communicate using the BACnet MS/TP protocol at speeds from 9600 to 115,200 baud (no parity). The meter shall provide a BACnet Device object, a set of writable Analog Value objects for remote configuration, a set of Analog Input objects to provide access to scaled 32-bit measurement values and their unit types, and a set of Binary Input objects for indicating individual alarm conditions.
5. The meter shall be UL/CUL listed to the latest applicable safety standards.
6. Power meter models shall accept voltage input over the range of 90 to 600 VAC (50 or 60 Hz).
7. The power meter shall accept 0 to 0.333VAC input from up to three current transducers (U018 Rope Style CTs only) from 20 to 5000 amps.
8. The measured energy consumption shall be retained in non-volatile memory for the life of the product warranty.
9. The power meter shall have demand measurement programmable for up to 6 sub-intervals of 10 seconds to 546 minutes duration.
10. Meter shall be optionally available in an outdoor NEMA 4X enclosure.
11. The power meter shall operate from -30°C to +70°C.
12. The power meter shall have dimensions not exceeding 4.2" x 3.6" x 2.3".
13. The power meter shall meet both ANSI C12.20 .5% and IEC 62053-22 Class .5S real power and energy accuracy specifications.
14. The power meter shall meet IEC 62053-22 Class 2 reactive power and energy accuracy specifications.
15. The power meter shall be configurable for operation on Single Phase (AN or AB), Split Phase (ABN), Delta (ABC), and Wye (ABCN) systems.
16. The power meter shall have automatic phase reversal compensation such that it is insensitive to the CT's load orientation.
17. The power meter shall have separate control power inputs such that it may be powered from a different service than it measures.
18. The power meter shall have Phase Loss Alarm contacts with a user configurable phase loss threshold.
19. The power meter shall have a user-configurable Pulse Contact input to support measurement of other related energy (Gas, Water, Steam, etc.) via BACnet using a simple pulse-output transducer.
20. The power meter shall be configurable for use with Potential Transformers to 5000 volts.

21. The power meter shall support warnings for low power factor (phase current or voltage miss-wired), current over range, voltage over range, and frequency out of range.
22. The product shall have a 5-year warranty.
23. The power meter shall be Veris E50H2 or equivalent.

M. Status and Safety Switches

1. General Requirements
  - a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
2. Current Sensing Switches
  - a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
  - b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
  - c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
3. Air Filter Status Switches
  - a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
  - b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
  - c. Provide appropriate scale range and differential adjustment for intended service.
4. Air Flow Switches
  - a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
5. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
  - a. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
6. Low Temperature Limit Switches
  - a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
  - b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
  - c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

2.9 OUTPUT DEVICES

A. Actuators

1. General Requirements
  - a. Damper and valve actuators shall be electronic. Controls submittals shall indicate actuator fail position as normally open or closed.
2. Electronic Damper Actuators
  - a. Electronic damper actuators shall be direct shaft mount.

- b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
        - c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
        - d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
  - 3. Electronic Valve Actuators
    - a. Electronic valve actuators shall be manufactured by the valve manufacturer.
    - b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
    - c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
    - d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
    - e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
- B. Control Relays
- 1. Control Pilot Relays
    - a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
    - b. Mounting Bases shall be snap-mount.
    - c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
    - d. Contacts shall be rated for 10 amps at 120VAC.

- e. Relays shall have an integral indicator light and check button.

## 2.10 FIREFIGHTERS' SMOKE CONTROL STATION

- A. A Fireman's Smoke Control Station (FSCS) shall be equal to Automation Displays, Inc. and provided for firefighter control and monitoring of the building's smoke control system in compliance with International Building Code and NFPA 92, "Standard for Smoke-Control Systems."
  - 1. The FSCS shall be UL Listed as a Firefighters Smoke Control Station under UL864 - UUKL for smoke control.
- B. The FSCS shall provide individual manual command switches and pilot lamps for each individual piece of operating smoke control equipment involved in the smoke control system on a custom building graphic panel.
  - 1. Panel face arrangement shall be similar to that shown on the building automatic system control schematics, and shall be submitted for review and approval prior to fabrication.
  - 2. A clear indication of the direction of airflow and the relationship of components shall be displayed. Status indicators shall be provided for all smoke control equipment, annunciated by fan and zone, and by pilot-lamp-type indicators as follows:
    - a. Fans, dampers and other operating equipment in their normal status – WHITE.
    - b. Fans, dampers and other operating equipment in their off or closed status – RED.
    - c. Fans, dampers and other operating equipment in their on or open status – GREEN.
    - d. Fans, dampers and other operating equipment in a fault status – YELLOW/AMBER.
- C. The FSCS shall communicate and interface to the HVAC control system and central operator's computer through the local area network (LAN).
- D. The FSCS shall include and monitor/control the following, with indicating pilot lights:
  - 1. Area of the building in alarm
  - 2. Fan on-off control (On-Auto-Off)
  - 3. Damper open-close control (Open-Auto-Close)
  - 4. Fan and damper status
- E. The FSCS shall consist of the following assemblies:
  - 1. Steel Enclosure with Hinged Locking Front Panel
  - 2. Graphic Panel with Pilot Lamps and Switches
  - 3. DIN Rail for Installation of PXC Modular Controller
  - 4. Plug-in Cabling
  - 5. Trunk and Input Power Terminals
- F. The fire-fighter's control panel actions shall be as follows:
  - 1. ON-OFF and OPEN-CLOSE control actions shall have the highest priority of any control point within the building.
    - a. Once issued from the fire fighter's control panel, automatic or manual control from any other control point within the building shall not contradict the control action.
    - b. Where automatic means are provided to interrupt normal, nonemergency equipment operation or produce a specific result to safeguard the building or equipment including, but not limited to, duct freezestats, duct smoke detectors, high-temperature cutouts, temperature-actuated linkage and similar devices, such means shall be capable of being overridden by the fire fighter's control panel.

- c. The last control action as indicated by each fire fighter's control panel switch position shall prevail. Control actions shall not require the smoke control system to assume more than one configuration at any one time.
- 2. Only the AUTO position of each three-position fire-fighter's control panel switch shall allow automatic or manual control action from other control points within the building.
  - a. The AUTO position shall be the NORMAL, nonemergency, building control position.
  - b. Where a fire fighter's control panel is in the AUTO position, the actual status of the device (on, off, open, closed) shall continue to be indicated by the status indicator.
  - c. Where directed by an automatic signal to assume an emergency condition, the NORMAL position shall become the emergency condition for that device or group of devices within the zone.
  - d. Control actions shall not require the smoke control system to assume more than one configuration at any one time.
- G. A general HVAC alarm light shall be provided on the panel face. The building automation system shall energize the light for high priority HVAC alarms (as defined by the owner).
- H. A pilot lamp test shall be provided for testing all pilot lamps on the FSCS. The FSCS shall be equipped with an audible annunciator to sound upon specific monitored conditions.
- I. A lockable security cover shall be provided.

## 2.11 MISCELLANEOUS DEVICES

- A. Local Control Panels
  - 1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
  - 2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
  - 3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
  - 4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
  - 5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
  - 6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.
- B. Thermostats
  - 1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

## 2.12 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

- A. Furnish local UPS units, of type indicated, installed with DDC system.

B. DIN Rail Mounted UPS:

1. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
2. Performance:
  - a. Capacity: Load not to exceed 75 percent of rated capacity.
  - b. Efficiency: Minimum 94 percent.
  - c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
  - d. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
  - e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
  - f. On Battery Output Voltage: Sine wave.
  - g. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
  - h. Battery Backup: Five minutes of operation at full load with battery power.
  - i. Battery Recharge Time: Maximum of six hours to 90 percent capacity after full discharge.
  - j. Transfer Time: 6 ms.
  - k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B.
3. Automatic bypass operation during fault or overload conditions.
4. Integral line-interactive, power condition topology to eliminate all power contaminants.
5. Include power switch and visual indication of power, battery, fault, and temperature.
6. Include audible alarm of faults with silence feature.
7. Include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect points to BAS system.
8. Batteries: Sealed; maintenance free; replacement without dropping load.

C. Tower UPS Models through 1000 VA:

1. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
2. Performance:
  - a. Capacity: Load not to exceed 75 percent of rated capacity.
  - b. Efficiency: Complying with ENERGY STAR requirements; minimum 91 percent.
  - c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
  - d. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
  - e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
  - f. On Battery Output Voltage: Sine wave.
  - g. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
  - h. Battery Backup: Five minutes of operation at full load with battery power.
  - i. Battery Recharge Time: Maximum of four hours to 90 percent capacity after full discharge to cutoff.
  - j. Transfer Time: 0 ms.
  - k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B; 6 kV/200 and 500 A; 100 kHz ring wave.
3. Automatic bypass operation during fault or overload conditions.
4. Integral line-interactive, power condition topology to eliminate all power contaminants.
5. Include power switch and visual indication of power, battery, fault, and temperature.
6. Include audible alarm of faults and front panel silence feature.
7. Receptacles: Minimum four>, NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
8. Remote Alarms: Include dry contacts (digital output points) or serial communication interface for low battery condition and battery-on (primary utility power failure) and connect points to BAS system.

9. Batteries: Sealed type; maintenance free. Battery replacement is to be front accessible by user without dropping load.
10. Install tower models in enclosures rated for location.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
  1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
  1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
  2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 BAS SPECIFIC REQUIREMENTS

- A. Graphic Displays
  1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
  2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.
- B. Actuation / Control Type
  1. Primary Equipment
    - a. Controls shall be provided by equipment manufacturer as specified herein.
    - b. All damper and valve actuation shall be electric.
  2. Rooftop Air Handling Equipment
    - a. All air handlers shall be controlled with a HVAC-DDC Controller
    - b. All damper and valve actuation shall be electric.
  3. Terminal Equipment:
    - a. Terminal Units (VAV, FCU etc.) shall have electric damper and valve actuation.
    - b. All terminal units shall be controlled with HVAC-DDC Controller.

#### 3.3 INSTALLATION

- A. BAS Wiring
  1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Automation, as herein specified, shall be provided by the BAS Contractor unless

specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.

2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.
3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
4. Class 2 Wiring
  - a. All Class 2 (24VAC or less) wiring shall be installed in conduit.
  - b. Conduit shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

B. BAS Raceway

1. All wiring shall be installed in blue conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
2. Where it is not possible to conceal raceways in finished locations, surface raceway (wiremold) may be used as approved by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

C. Penetrations

1. Provide fire stopping for all penetrations used by dedicated BAS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

D. BAS Panel Installation

1. The BAS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. The BAS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

E. Input Devices

1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BAS in accessible local control panels wherever possible.

F. HVAC Input Devices – General

1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BAS in accessible local control panels wherever possible.

3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
5. Outside Air Sensors
  - a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
  - b. Sensors shall be installed with a rain proof, perforated cover.
6. Water Differential Pressure Sensors
  - a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
  - b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
  - c. The transmitters shall be installed in an accessible location wherever possible.
7. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
  - a. Air bleed units, bypass valves and compression fittings shall be provided.
8. Building Differential Air Pressure Applications (-1" to +1" w.c.):
  - a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
  - b. The interior tip shall be inconspicuous and located as shown on the drawings.
9. Duct Temperature Sensors:
  - a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
  - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
  - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
  - d. The sensor shall be mounted to suitable supports using factory approved element holders.
10. Space Sensors:
  - a. Shall be coordinated with Architectural plans and mounted per ADA requirements.
  - b. In public areas and/or where indicated on plans, provide sensors without controls interface, and/or a lockable interface.
  - c. Space air temperature sensors shall be provided in all Electrical, AV, IT, Data, Telecom (TR) and Server rooms. Sensors shall be provided with digital display of sensed temperature.
11. Low Temperature Limit Switches:
  - a. Install on the discharge side of the first water or steam coil in the air stream.
  - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
  - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
12. Air Differential Pressure Status Switches:
  - a. Static pressure tips, tubing, fittings, and air filter.
13. Water Differential Pressure Status Switches:
  - a. with shut off valves for isolation.
14. Do not cover or conceal sensors with insulation.

G. HVAC Output Devices

1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
3. Control Valves:
  - a. Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
  - b. Install valves in piping with stems as vertical as possible but in no case less than forty-five (45) degrees from vertical. For soldered or welded connections, remove valve internals before installation.
  - c. Wire electric valves in accordance with NFPA 70 with not less than two (2) feet of flexible liquidtight connector with watertight bushings at the valve actuator and conduit termination. Brace conduit to the building structure to prevent movement and damage.
4. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Automation is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems.

H. Label Installation

1. Install or permanently fasten labels on each major item of temperature control equipment.
2. Locate labels where accessible and visible.
3. For equipment, devices, sensors, etc. located above the ceiling, in addition to a label on the equipment, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit.

3.4 TRAINING

- A. The manufacturer shall provide a factory trained instructor to give not less than 8 hours of full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach.
- B. Provide training for Owner's designated operating personnel. Training shall include:
  1. Explanation of drawings, operations and maintenance manuals
  2. Walk-through of the job to locate control components
  3. Operator workstation and peripherals
  4. DDC controller and ASC operation/function
  5. Operator control functions including graphic generation and field panel programming
  6. Explanation of adjustment, calibration and replacement procedures
  7. Electronic Catalog and Materials
- C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If such training is required by the Owner, it will be contracted at a later date.

3.5 COMMISSIONING, TESTING AND ACCEPTANCE

- A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning.

- B. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required.
- C. The commissioning must be coordinated with the owner and contractor to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.
  - 1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications, and approved shop drawings. Test, calibrate and bring online each control sensor and device. Commissioning to include, but not be limited to:
    - a. Sensor accuracy at 10, 50 and 90% of range.
    - b. Sensor range.
    - c. Verify analog limit and binary alarm reporting.
    - d. Point value reporting.
    - e. Binary alarm and switch settings.
    - f. Actuator ranges.
    - g. Fail safe operation on loss of control signal, electric power, network communications.
- D. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BAS program shall be put online and commissioned. The BAS contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracies. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.
- E. After all BAS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:
  - 1. Data communication, both normal and failure modes.
  - 2. Fully loaded system response time.
  - 3. Impact of component failures on system performance and system operation.
  - 4. Time/Date changes.
  - 5. End of month/ end of year operation.
  - 6. Season changeover.
  - 7. Global application programs and point sharing.
  - 8. System backup and reloading.
  - 9. System status displays.
  - 10. Diagnostic functions.
  - 11. Power failure routines.
  - 12. Battery backup.
  - 13. Smoke Control, stair pressurization, stair, vents, in concert with Fire Alarm System testing (if applicable).
  - 14. Testing of all electrical and HVAC systems with other division of work.
- F. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracies and the system performance does not degrade over time.

- G. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.
- H. The contractor shall supply all instruments for testing.
  - 1. Test Instrument Accuracy:
    - a. Temperature:  $\frac{1}{4}$  °F or  $\frac{1}{2}$ % full scale, whichever is less.
    - b. High Pressure:  $\frac{1}{2}$  psi or  $\frac{1}{2}$ % full scale, whichever is less.
    - c. Low Pressure:  $\frac{1}{2}$ % full scale
    - d. Humidity: 2% RH
    - e. Electrical:  $\frac{1}{4}$ % full scale
- I. After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

### 3.6 TEMPERATURE CONTROL

- A. The control sequence of operations describe the general operational intent of the control systems. Provide all hardware, software, devices, equipment and wiring as required to perform the operational intent described by the various control sequences and to fully interface with the building automation system (BAS).
- B. The control diagrams indicate the general arrangement of system components to the extent that they affect process flow or control. Not all required components are shown on the control diagrams. The contractor shall thoroughly review all contract documents to ascertain the full scope of their work.
- C. A full communication interface and complete interoperability with the BAS shall be provided to perform the functions herein described or indicated in the contract documents.
- D. For equipment with factory controllers:
  - 1. The BAS provider and the equipment manufacturer shall provide a complete list of all BACNET points available to be accessed from within the manufacturer's factory controllers and, specifically, identify what points can be read from the BAS, which points can be written too and which points cannot be accessed at all.
  - 2. The BAS submittal, sequences and points list shall indicate routines that are controlled completely from the manufacturer's controllers, which routines are controlled partially by the manufacturer's controllers and BAS and which routines are controlled completely by the BAS.
  - 3. The BAS provider and equipment manufacturer, in collaboration, shall provide coordinated submittals that indicate anything that has to be set, reset or accessed in a manufacturer's controller at the piece of equipment as opposed to being accessed at or from the BAS user interface/controller console. This coordination and collaboration shall occur at the submittal phase and well before equipment and controls are delivered to the site.
- E. Unless otherwise noted, size all automatic control valves for maximum ten (10) feet water pressure drop at maximum design flow rate.

- F. Refer to drawings for locations of all terminal units, room sensors, panels, dampers, valves, and equipment; where such devices are not indicated, however are required by the control sequences to achieve the intended operation, they shall be provided and located in the field where directed by the engineer.
- G. Division 26 shall provide all detection devices (heat/smoke) as required by the contract documents. Division 23 shall install all detection devices including required control and power wiring required for mechanical systems. Detection devices shall provide automatic shutdown of the HVAC systems in accordance with the International Mechanical Code.
- H. All pumps and fans shall be provided with a differential pressure sensor installed around the pump or fan. Sensor shall provide status indication for pump or fan operation. Current sensors with VA memory may be used instead of differential pressure sensors where indicated or noted.
- I. Adjustable freezestats shall be provided at all preheat and heating coils and shall de-energize their respective air handling system when their setting of 35°F is reached. Freezestats for water coils shall be installed in the coil leaving air stream. Freezestats shall be hard wired in the motor starter circuit and send an alarm signal to the BAS when they are activated.
- J. All temperature, humidity, pressure, time, etc. set points shall be fully adjustable through the BAS. Final system setpoints will be confirmed through system commissioning and fixed prior to building occupancy. Thereafter setpoints shall be adjustable through the BAS by trained maintenance staff.
- K. All two position dampers and valves shall be proven open by the use of end switches.
- L. All control devices located within chemical storage areas shall be explosion proof suitably rated for each specific application.
- M. Refer to individual input/output summary schedules for additional control devices not specifically described in the control narratives. Input/output summary schedules are minimum requirements; provide all required points for complete operation of the systems.
- N. All variable frequency drives (VFD) for fans and pumps shall be soft started at minimum speed and increased to required operating speed by the BAS.
- O. Refer to drawings for fans that shall be equipped with an inlet air monitoring device (AMD). Where provided, the BAS shall continuously monitor the airflow rate for the fan. AMD's for exhaust fans shall be of a material suitable for the intended airstream.
- P. Upon failure of any direct digital control (DDC) unit, an alarm shall be indicated on the BAS and the system shall automatically revert to the default cycle. All motors and fans shall remain in their last commanded state. When emergency power is available, the BAS shall monitor each essential power transfer switch and ramp the VFD's of selected fans and pumps to their lower limits until the emergency generator is stable and online; at which time the normal sequence of operations shall resume for selected fans and pumps.
- Q. In general and unless otherwise noted, heating control valves shall fail open, specialist area heating control valves shall fail closed, steam control valves shall fail closed, chilled water control valves shall fail closed. Isolation dampers at fans and air units shall fail open.

- R. Standby chillers, boilers, heat pumps, fans and pumps shall be alternated into operation every 500 hours. The BAS shall alarm for change over; actual change over shall be initiated by trained maintenance personnel through the BAS.
- S. HVAC system controls shall not fail and lock out upon loss of power (such as under emergency conditions) and loss of power shall not be alarmed to the BAS.
- T. Where used to control both comfort heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or dead band of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Variable air volume (VAV) terminal units shall be programmed to operate at the minimum airflow setting without addition of reheat when the zone temperature is within the set dead band.

END OF SECTION 230900

## SECTION 23 31 13 - METAL DUCTS

### 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. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Double-wall round ducts and fittings.
4. Insulated flexible ducts.
5. Flexible duct connectors.
6. Sheet metal materials.
7. Sealant and gaskets.
8. Hangers and supports.

- B. Related Sections:

1. Section 099113 "Exterior Painting" and Section 099123 "Interior Painting".
2. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
3. Section 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Ducts
2. Duct Connectors
3. Liners and adhesives.
4. Sealants and gaskets.

- B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.

8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

#### 1.4 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. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
  2. Suspended ceiling components.
  3. Structural members to which duct will be attached.
  4. Size and location of initial access modules for acoustical tile.
  5. Penetrations of smoke barriers and fire-rated construction.
  6. Items penetrating finished ceiling including the following:
    - a. Lighting fixtures.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Access panels.
    - f. Perimeter moldings.
- B. Welding certificates.
- C. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
  1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

## PART 2 - PRODUCTS

## 2.1 SINGLE-WALL 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."

## 2.2 SINGLE-WALL 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. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. 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.
- D. 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 in diameter with butt-welded longitudinal seams.
  - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

- E. 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."

## 2.3 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Source Limitations: Obtain double-wall round ducts and fittings from single manufacturer.
- B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
  - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
  - 2. Transverse Joints: Fabricate in accordance with 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."
    - a. Transverse joints must be "Beaded Sleeve" type. Flanged joints are not acceptable.
  - 3. Longitudinal Seams: Select seam types and fabricate in accordance with 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."
    - a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
    - b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
  - 4. Tees and Laterals: Select types and fabricate in accordance with 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."
- C. Inner Duct: Minimum 24-gauge (0.7-mm) perforated galvanized sheet steel having 3/32-inch (2.4-mm-) diameter perforations, with overall open area of 23 percent.
- D. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
  - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
  - 3. Coat insulation with antimicrobial coating.

4. Cover insulation with polyester film complying with UL 181, Class 1.

## 2.4 INSULATED FLEXIBLE DUCTS

- A. Available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
  1. Thermaflex.
- B. Insulated, Flexible Duct: UL 181, Class 1, coated fiberglass woven fabric supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
- C. Pressure Rating: 10-inch wg positive and 2.0-inch wg negative.
- D. Maximum Air Velocity: 4000 fpm (20 m/s).
- E. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- F. Insulation R-Value: R4.2.

## 2.5 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

## 2.6 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. Galvanized Coating Designation: G60.
  2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. 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.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.7 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: 4 inches.
  - 3. Sealant: Modified styrene acrylic.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 7. Service: Indoor and outdoor.
  - 8. Service Temperature: Minus 40 to plus 200 deg F.
  - 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).
  - 11. 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."
- 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, 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.
- 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 and shall be rated for 10-inch wg 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.

## 2.8 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.

## 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 round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.

- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.
- L. 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 FLEXIBLE DUCT INSTALLATION

- A. Install flexible ducts 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.
- B. Install in indoor applications only. Flexible ductwork should not be exposed to UV light.
- C. Connect diffusers with maximum 60-inch (1500-mm) lengths of flexible duct clamped in place.
- D. Connect flexible ducts to metal ducts with liquid adhesive plus tape.
- E. Install duct test holes where required for testing and balancing purposes.
- F. Installation:
  - 1. Install ducts fully extended.
  - 2. Do not bend ducts across sharp corners.
  - 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
  - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
  - 5. Install flexible ducts in a direct line, without sags, twists, or turns.
- G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches (1800 mm) o.c.

### 3.3 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. 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.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.
- F. Flexible ductwork not permitted where exposed in finished spaces.

### 3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. 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 C.
  5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
  6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
  7. Unconditioned Space, Exhaust Ducts: Seal Class C.
  8. Unconditioned Space, Return-Air Ducts: Seal Class B.
  9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
  10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.

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 thick.
  4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: 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," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- 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 interval of 16 feet.
- 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 complying with Section 23 33 00 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### 3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 09 91 13 "Exterior Painting" and Section 09 90 00 "Painting."
- B. Paint exterior of metal ducts located within or visible from finished spaces. Paint exterior of metal ducts located within or visible from finished spaces. Architect to provide paint color and finish. Apply paint over a compatible galvanized-steel primer per manufacturer's instructions. Paint materials and application requirements are specified in Section 09 91 23 "Interior Painting."

### 3.8 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 with 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. Test for leaks before applying external insulation.
  - 5. 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.
  - 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
  - 1. Visually inspect duct system to ensure that no visible contaminants are present.
  - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

### 3.9 START UP

- A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

### 3.10 DUCT SCHEDULE

- A. Supply Ducts:
  - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive 1-inch wg.
    - b. Minimum SMACNA Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: 12.

- d. 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. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 6.
    - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- B. Return Ducts:
  - 1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: C.
    - c. SMACNA Leakage Class for Rectangular: .
    - d. 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. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- C. Exhaust Ducts:
  - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - a. Pressure Class: Negative 3-inch wg.
    - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 24.
    - d. SMACNA Leakage Class for Round: 12.
  - 2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 3-inch wg
    - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round: 12.
- D. Intermediate Reinforcement:
  - 1. Galvanized-Steel Ducts: Galvanized steel.
  - 2. PVC-Coated Ducts:
  - 3. Aluminum Ducts: Aluminum.
- E. 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 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:
      - 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 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 or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      - 3) Velocity 1500 fpm 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, and Smaller in Diameter: Stamped or pleated.
    - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- F. 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 and Flat Oval: 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 or Lower: 90-degree tap.
  - b. Velocity 1000 to 1500 fpm: Conical tap.
  - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

## SECTION 233300 - AIR DUCT ACCESSORIES

### 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. Backdraft and pressure relief dampers.
  - 2. Manual volume dampers.
  - 3. Control dampers.
  - 4. Smoke dampers.
  - 5. Flange connectors.
  - 6. Turning vanes.
  - 7. Flexible connectors.
  - 8. Duct accessory hardware.

- B. Related Requirements:

- 1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
  - 2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
  - 3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

#### 1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: For duct accessories. 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. Special fittings.
    - b. Manual volume damper installations.
    - c. Control-damper installations.
    - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
    - e. Include diagrams for power, signal, and control wiring.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- 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 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating (AWV); Mestek, Inc.
  - 2. Greenheck Fan Corporation.
  - 3. Lloyd Industries, Inc.
  - 4. Nailor Industries Inc.
  - 5. Pottorff.
  - 6. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
  - 7. Vent Products Co., Inc.
- B. Description: Gravity balanced.
- C. Performance:
  - 1. Maximum Air Velocity: 2000 fpm.
  - 2. Maximum System Pressure: 2 inches wg.
  - 3. Leakage:
    - a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
- D. Construction:
  - 1. Frame:
    - a. Hat shaped.
    - b. 16-gauge-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
  - 2. Blades:

- a. Multiple single-piece blades.
  - b. Center pivoted, maximum 6-inch width, 16-gauge-thick, galvanized sheet steel with sealed edges.
- 3. Blade Action: Parallel.
- E. Blade Seals: Extruded vinyl or neoprene, mechanically locked.
- F. Blade Axles:
  - 1. Material: Galvanized steel.
  - 2. Diameter: 0.20 inch.
- G. Tie Bars and Brackets: Galvanized steel.
- H. Return Spring: Adjustable tension.
- I. Bearings: Steel ball or synthetic pivot bushings.

## 2.3 MANUAL VOLUME DAMPERS

- A. Low-Leakage, Steel, Manual Volume Dampers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. American Warming and Ventilating (AWV); Mestek, Inc.
    - b. Greenheck Fan Corporation.
    - c. Lloyd Industries, Inc.
    - d. McGill AirFlow LLC.
    - e. Nailor Industries Inc.
    - f. Pottorff.
    - g. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
    - h. Vent Products Co., Inc.
  - 2. Performance:
    - a. Leakage:
      - 1) Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
  - 3. Construction:
    - a. Linkage: Out of airstream.
    - b. Suitable for horizontal or vertical airflow applications.
  - 4. Frames:
    - a. Hat, U, or angle shaped.
    - b. Thickness: 16-gauge galvanized sheet steel.
    - c. Mitered and welded corners.

- d. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:
  - a. Multiple or single blade.
  - b. Parallel- or opposed-blade design.
  - c. Stiffen damper blades for stability.
  - d. Galvanized, roll-formed steel; 16 gauge thick.
- 6. Blade Edging Seals:
  - a. Closed-cell neoprene.
  - b. Inflatable seal blade edging or replaceable rubber seals.
- 7. Blade Jamb Seals: Flexible metal compression type.
- 8. Blade Axles: Galvanized steel.
- 9. Bearings:
  - a. Oil-impregnated bronze or Molded synthetic.
  - b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
- 10. Tie Bars and Brackets: Galvanized steel.
- 11. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:

- 1. Size: 0.5-inch 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-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
- 2. Include center hole to suit damper operating-rod size.
- 3. Include elevated platform for insulated duct mounting.

## 2.4 CONTROL DAMPERS

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

- 1. American Warming and Ventilating (AWV); Mestek, Inc.
- 2. Greenheck Fan Corporation.
- 3. Lloyd Industries, Inc.
- 4. McGill AirFlow LLC.
- 5. Nailor Industries Inc.
- 6. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
- 7. Vent Products Co., Inc.

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:

1. Leakage:
  - a. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
3. Velocity: Up to 3000 fpm.
4. Temperature: Minus 25 to plus 180 deg F.
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
  - a. Hat, U, or angle shaped.
  - b. 16-gauge-thick, galvanized sheet steel.
  - c. Interlocking, gusseted corners.
  - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
  - a. Multiple blade with maximum blade width of 6 inches.
  - b. Opposed-blade design.
  - c. Galvanized steel.
  - d. 16-gauge-thick single skin or 14-gauge-thick air foil dual skin.
5. Blade Edging Seals:
  - a. Replaceable Closed-cell neoprene.
6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:
  - a. Oil-impregnated bronze or Molded synthetic.
  - b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

E. Damper Actuator - Electric:

1. Electric - 24 V ac.
2. UL 873, plenum rated.
3. Fully modulating.
  - a. Sufficient motor torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
  - b. Minimum 90-degree drive rotation.
4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:
  - a. Temperature: Minus 40 to plus 130 deg F.
  - b. Humidity: 5 to 95 percent relative humidity noncondensing.
6. Environmental enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

F. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 24 V, 60 Hz.

## 2.5 SMOKE 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. Ruskin; Air Distribution Technologies, Inc.
2. Air Balance; MESTEK, Inc.
3. Aire Technologies, Inc.; DMI Companies.
4. Greenheck Fan Corporation.
5. Pottorff.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

C. Performance:

1. Leakage:

- a. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s/ per sq. m) against 1-inch wg (250-Pa) differential static pressure.
  2. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
  3. Velocity: Up to 3000 fpm (15 m/s).
  4. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
  5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
- D. Construction:
1. Suitable for horizontal or vertical airflow applications.
  2. Linkage out of airstream.
  3. Frame:
    - a. Hat shaped.
    - b. Galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.
    - c. Gauge in accordance with UL listing.
  4. Blades:
    - a. Roll-formed, horizontal, galvanized sheet steel.
    - b. Maximum width and gauge in accordance with UL listing.
  5. Blade Edging Seals:
    - a. Silicone rubber.
  6. Blade Jamb Seal: Flexible stainless steel, compression type.
  7. Blade Axles: 1/2-inch (13-mm) diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
  8. Bearings:
    - a. Oil-impregnated bronze.
- E. Damper Actuator - Electric:
1. Electric - 120 V ac.
  2. UL 873, plenum rated.
  3. Designed to operate in smoke-control systems complying with UL 555S requirements.
  4. Two position with fail-safe spring return.
    - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    - b. Maximum 15-second full-stroke closure.
    - c. Minimum 90-degree drive rotation.
  5. Clockwise or counterclockwise drive rotation as required for application.
  6. Environmental Operating Range:

- a. Temperature: Minus 40 to plus 130 deg F ((Minus 40 to plus 55 deg C)).
    - b. Humidity: 5 to 95 percent relative humidity noncondensing.
  - 7. Environmental Enclosure: NEMA 2.
  - 8. Actuator to be factory mounted and provided with single-point wiring connection.
- F. Accessories:
- 1. Smoke Detector: Integral, factory wired for single-point connection.

## 2.6 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. CL WARD & Family Inc.
  - 2. Ductmate Industries, Inc; a DMI company.
  - 3. DynAir; a Carlisle Company.
  - 4. Elgen Manufacturing.
  - 5. Ward Industries; a brand of Hart & Cooley, LLC.
- B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

## 2.7 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. CL WARD & Family Inc.
  - 2. Ductmate Industries, Inc; a DMI company.
  - 3. Duro Dyne Inc.
  - 4. DynAir; a Carlisle Company.
  - 5. Elgen Manufacturing.
  - 6. Ward Industries; a brand of Hart & Cooley, LLC.
- B. Manufactured Turning Vanes for Metal Ducts: Fabricate 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.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vaness and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

- E. Vane Construction:

- 1. Single wall.

## 2.8 DUCT ACCESS PANEL ASSEMBLIES

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

- 1. CL WARD & Family Inc.
  - 2. Ductmate Industries, Inc; a DMI company.
  - 3. Flame Gard, Inc.

- B. Access panels used in cooking applications:

- 1. Labeled compliant to NFPA 96 for grease duct access doors.
  - 2. Labeled in accordance with UL 1978 by an NRTL.

- C. Panel and Frame: Minimum thickness 16-gauge carbon steel.

- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

- E. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

- F. Minimum Pressure Rating: 10 inches wg positive or negative.

## 2.9 FLEXIBLE CONNECTORS

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

- 1. CL WARD & Family Inc.
  - 2. Ductmate Industries, Inc; a DMI company.
  - 3. Duro Dyne Inc.
  - 4. DynAir; a Carlisle Company.
  - 5. Elgen Manufacturing.
  - 6. Ward Industries; a brand of Hart & Cooley, LLC.

- B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

- D. Materials: Flame-retardant or noncombustible fabrics.

- E. Coatings and Adhesives: Comply with UL 181, Class 1.
- F. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- G. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd..
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.

## 2.10 DUCT ACCESSORY HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. CL WARD & Family Inc.
  - 2. Ductmate Industries, Inc; a DMI company.
  - 3. Duro Dyne Inc.
  - 4. DynAir; a Carlisle Company.
  - 5. Elgen Manufacturing.
  - 6. Ward Industries; a brand of Hart & Cooley, LLC.
- B. 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.
- C. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

## 2.11 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
  - 1. Galvanized Coating Designation: G60.
  - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. 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.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. 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.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- H. Install fire and smoke dampers in accordance with UL listing.
- I. 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. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - 4. 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.
  - 5. Control devices requiring inspection.
  - 6. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
  - 1. One-Hand or Inspection Access: 8 by 5 inches.
  - 2. Two-Hand Access: 12 by 6 inches.
  - 3. Head and Hand Access: 18 by 10 inches.
  - 4. Head and Shoulders Access: 21 by 14 inches.

- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. 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 size and location of access doors are adequate to perform required operation.
  - 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
  - 4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
  - 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

## SECTION 233400 - HVAC FANS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Fans, centrifugal, inline – tubular.
2. Ventilators, centrifugal - roof-mounted upblast.
3. Fans, propeller – sidewall mounted.

#### 1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
  - a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
  - b. Rated capacities, furnished specialties, and accessories for each fan.
  - c. Fans:
    - 1) Certified fan performance curves with system operating conditions indicated.
    - 2) Certified fan sound-power ratings.
    - 3) Fan construction and accessories.
    - 4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
    - 5) Fan speed controllers.
  - d. Material thickness and finishes, including color charts.
  - e. Dampers, including housings, linkages, and operators.

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 for designing vibration isolation bases.
5. 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 vibration isolation 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 supports.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Startup service reports.
- B. Field quality-control reports.

### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fans and ventilators, include the following:
  1. Operation and maintenance manuals.

## 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. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

### 2.2 FANS, CENTRIFUGAL, INLINE - TUBULAR

- 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. Aerovent; a division of Twin City Fan Companies, Ltd.
  2. Loren Cook Company.
  3. Fantech (Basis of Design).
  4. PennBarry; division of Air System Components.
- B. Source Limitations: Obtain tubular in-line centrifugal fans from single manufacturer.
- C. Description: Tubular-housing in-line centrifugal fans.
- D. Housing:
  1. Housing Material: Aluminum.

- E. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- F. Fan Wheels: Steel, airfoil blades welded to aluminum hub.
- G. Accessories:
  - 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
  - 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
  - 4. Companion Flanges: For inlet and outlet duct connections.
  - 5. Motor Cover: Epoxy-coated steel.

## 2.3 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED UPBLAST OR SIDEWALL MOUNTED

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Aerovent; a division of Twin City Fan Companies, Ltd.
  - 2. Canarm Ltd.
  - 3. Greenheck Fan Corporation (Basis of Design).
  - 4. Loren Cook Company.
- B. Source Limitations: Obtain roof-mounted upblast or sidewall-mounted centrifugal ventilators from single manufacturer.
- C. Standards:
  - 1. Comply with UL 705.
- D. Configuration: Centrifugal roof upblast ventilator.
- E. 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.
- F. Fan Wheels: Aluminum hub and wheel with backward-inclined blades, Type A.
- G. Accessories:
  - 1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
  - 3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
  - 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

5. Mounting Pedestal: Galvanized steel with removable access panel.

H. 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.

1. Configuration: Manufactured to accommodate roof slope.

## 2.4 FANS, PROPELLER - SIDEWALL MOUNTED

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. Twin City Fan (Basis of Design).
2. Carnes Company.
3. Loren Cook Company.

B. Source Limitations: Obtain sidewall-mounted propeller fans from single manufacturer.

C. Standards: Comply with UL 705.

D. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

E. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

F. Fan Drive, Direct: Direct-drive electronically commutated motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

G. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
3. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
4. Wall Sleeve: Galvanized steel to match fan and accessory size.
5. Weathershield Hood: Galvanized steel to match fan and accessory size.

## 2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

## 2.6 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 Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.
- C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.
- D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION, GENERAL

- A. Install fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
  - 1. Unit Support: Install fans level on structural curbs. Coordinate with duct connections.
- E. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.
- F. Install units with adequate 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."
- B. Where installing ducts adjacent to fans, allow space for service and maintenance.

#### 3.3 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

### 3.4 STARTUP SERVICE:

#### A. 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 damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. 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.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

### 3.5 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.

### 3.6 FIELD QUALITY CONTROL

- #### A.
- Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.
- #### B.
- Perform tests and inspections with the assistance of a factory-authorized service representative.
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.

### 3.7 DEMONSTRATION

- #### A.
- Train Owner's maintenance personnel to adjust, operate, and maintain HVAC fans.

END OF SECTION 233400

## SECTION 233600 - AIR TERMINAL UNITS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Modulating, single-duct air terminal units.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air terminal units.
  - 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.
  - 4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

#### 1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units 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. Instructions for resetting minimum and maximum air volumes.
    - b. Instructions for adjusting software set points.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.

- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

## 2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Johnson Controls, Inc.
  - 2. Nailor Industries Inc.
  - 3. Price Industries Limited.
  - 4. Titus; brand of Johnson Controls International plc, Global Products.
- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: Minimum 22-gauge- thick galvanized steel.
  - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for with "Solid Metal Liner" Subparagraph.
  - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
  - 3. Air Outlet: S-slip and drive connections.
  - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
  - 1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 3-inch wg inlet static pressure.
- E. Velocity Sensors: Multipoint array with velocity inlet sensors.
- F. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
  - 1. SCR controlled.
  - 2. Access door interlocked disconnect switch.
  - 3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
  - 4. Nickel chrome 80/20 heating elements.
  - 5. Airflow switch for proof of airflow.
  - 6. Fan interlock contacts.
  - 7. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).
- G. Direct Digital Controls:

1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
  - a. Occupied and unoccupied operating mode.
  - b. Remote reset of airflow or temperature set points.
  - c. Adjusting and monitoring with portable terminal.
  - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230923 "Direct Digital Controls (DDC) for HVAC."

## 2.3 CASING LINER

- A. Casing Liner, Fibrous Glass: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A or NFPA 90B, and with NAIMA AH124.
  1. Minimum Thickness: 1/2 inch.
    - a. Maximum Thermal Conductivity:
      - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
  2. Solid Metal Liner: Solid galvanized sheet metal encapsulating matted insulation face from airstream.
  3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

## 2.4 SOURCE QUALITY CONTROL

- A. AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.
- B. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.
- C. Water Coils: Factory pressure test to 300 psig in accordance with AHRI 410 and ASHRAE 33.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, GENERAL

- A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.
- B. Install air terminal units according to NFPA 90A.
- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- D. Install wall-mounted thermostats.

### 3.2 DUCTWORK CONNECTIONS

- A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

### 3.3 ELECTRICAL CONNECTIONS

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

### 3.4 CONTROL CONNECTIONS

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

### 3.5 IDENTIFICATION

- A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows, and coil type. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

### 3.6 STARTUP SERVICE

- A. Perform startup service.
  - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
  - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
  - 3. Verify that controls and control enclosure are accessible.
  - 4. Verify that control connections are complete.
  - 5. Verify that nameplate and identification tag are visible.
  - 6. Verify that controls respond to inputs as specified.

### 3.7 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

END OF SECTION 233600

## SECTION 233713.13 - AIR DIFFUSERS

### 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. Rectangular and square ceiling diffusers.
  - 2. Louver face diffusers.
  - 3. Linear slot diffusers.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
  - 2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 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 Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

### PART 2 - PRODUCTS

#### 2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
  - 2. Nailor Industries Inc.
  - 3. Price Industries Limited.
  - 4. Titus; brand of Johnson Controls International plc, Global Products.
- B. Devices shall be specifically designed for variable-air-volume flows.

- C. Material: Steel.
- D. Finish: Baked enamel, color selected by Architect.
- E. Face Size: 24 by 24 inches.
- F. Face Style: Plaque.
- G. Mounting: T-bar.
- H. Pattern: Fixed.

## 2.2 LOUVER FACE DIFFUSERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. METALAIRE, Inc.
  - 2. Nailor Industries Inc.
  - 3. Price Industries Limited.
  - 4. Titus; brand of Johnson Controls International plc, Global Products.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Steel.
- D. Finish: Baked enamel, color selected by Architect.
- E. Face Size: As defined on schedule.
- F. Mounting: T-bar.
- G. Pattern: Four-way Adjustable core style.
- H. Dampers: Radial opposed blade.
- I. Accessories:
  - 1. Square to round neck adaptor.
  - 2. Adjustable pattern vanes.
  - 3. Equalizing grid.

## 2.3 LINEAR SLOT DIFFUSERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
  - 2. METALAIRE, Inc.
  - 3. Nailor Industries Inc.
  - 4. Titus; brand of Johnson Controls International plc, Global Products.

- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material - Shell: Steel, insulated.
- D. Material - Pattern Controller and Tees: Aluminum.
- E. Finish - Face and Shell: Baked enamel, black.
- F. Finish - Pattern Controller: Baked enamel, black.
- G. Finish - Tees: Baked enamel, color selected by Architect.
- H. Slot Width: 3/4 inch.
- I. Number of Slots: Two.
- J. Length: 48 inches.

#### 2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers 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 are 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 level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: 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 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 to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

## SECTION 233713.23 - 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. Section Includes:
  - 1. Fixed face registers and grilles.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
  - 2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 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. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

### PART 2 - PRODUCTS

#### 2.1 REGISTERS

- A. Fixed Face Register:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
    - b. METALAIR, Inc.
    - c. Nailor Industries Inc.
    - d. Price Industries Limited.
    - e. Titus; brand of Johnson Controls International plc, Global Products.
  - 2. Material: Steel.
  - 3. Finish: Baked enamel, color selected by Architect.

4. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
5. Face Arrangement: Perforated core.
6. Core Construction: Integral.
7. Frame: 1-1/4 inches wide.
8. Mounting: Countersunk screw.

## 2.2 GRILLES

### A. Fixed Face Grille:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
  - b. METALAIR, Inc.
  - c. Nailor Industries Inc.
  - d. Price Industries Limited.
  - e. Titus; brand of Johnson Controls International plc, Global Products.
2. Material: Steel.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
5. Face Arrangement: Perforated core.
6. Core Construction: Integral.
7. Frame: 1-1/4 inches wide.
8. Mounting: Countersunk screw.

## 2.3 SOURCE QUALITY CONTROL

- ### A. Verification of Performance: Rate 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 registers and grilles are 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 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 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 registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

## SECTION 237416.13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components:
  - 1. Casings.
  - 2. Fans, drives, and motors.
  - 3. Coils.
  - 4. Refrigerant circuit components.
  - 5. Air filtration.
  - 6. Dampers.
  - 7. Electrical power connections.
  - 8. Controls.
  - 9. Roof curbs.
  - 10. Accessories.

#### 1.3 DEFINITIONS

- A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each RTU.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
  - 3. Include unit dimensions and weight.
  - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
  - 5. Fans:
    - a. Include certified fan-performance curves with system operating conditions indicated.
    - b. Include certified fan-sound power ratings.
    - c. Include fan construction and accessories.
    - d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
  7. Include filters with performance characteristics.
  8. Include factory selection calculations for each antimicrobial ultraviolet lamp installation.
  9. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning units.
1. Include plans, elevations, sections, and mounting attachment details.
  2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU 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. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
  2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates, for RTUs, 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. Restraint of internal components.
- D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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.
- E. Source quality-control reports.

- F. System startup reports.
- G. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

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

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- 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. Filters: One set(s) of filters for each unit.
  - 2. Gaskets: One set(s) for each access door.
  - 3. Fan Belts: One set(s) for each belt-driven fan.
  - 4. Filters: One set(s) of filters for each unit.

#### 1.8 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: 10 year(s) from date of Substantial Completion.
  - 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and 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 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance: Comply with UL 1995.

- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

## 2.2 MANUFACTURERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.3 ROOFTOP UNIT

### A. General

1. The units shall be configured for airflow as indicated on the drawings. The operating range shall be between 115°F and 0°F in cooling as standard from the factory for all units. Cooling performance shall be rated in accordance with ARI testing procedures. All units shall be factory assembled, internally wired, fully charged with R-454B, and 100 percent run tested to check cooling operation, fan and blower rotation and control sequence, before leaving the factory. Wiring internal to the unit shall be colored and numbered for simplified identification. Units shall be UL listed and labeled, classified in accordance to UL 1995/C 22.2, 236-05 3rd Edition.
2. Packaged Rooftop units cooling, heating capacities, and efficiencies are AHRI certified within scope of AHRI Standard 340/360 (I-P) and ANSI Z21.47 and 10 CFR Part 431 pertaining to Commercial Warm

### B. Casing

1. Unit casing shall be constructed of zinc coated, heavy gauge, galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be tested 672 hours in a salt spray test in compliance with ASTM B117. Cabinet construction shall allow for all maintenance on one side of the unit. In order to ensure a water and air tight seal, service panels shall have lifting handles and no more than three screws to remove. All exposed vertical panels and top covers in the indoor air section shall be insulated with a 1/2 inch, 1 pound density foil-faced, fire-resistant, permanent, odorless, glass fiber material. The base of the unit shall be insulated with 1/2 inch, 1 pound density foil-faced, closed-cell material. The unit's base pan shall have no penetrations within the perimeter of the curb other than the raised 1 1/8 inch high supply/return openings to provide an added water integrity precaution, if the condensate drain backs up. The base of the unit shall have provisions for forklift and crane lifting.
2. The top cover shall be one piece, or where seams exist, double hemmed and gasket sealed to prevent water leakage.

### C. Filters

1. Two-inch pleated filters shall be factory supplied.

### D. Compressors

1. Unit shall have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of nameplate voltage. Internal overloads shall be provided with

the scroll compressors. All models shall have crankcase heaters, phase monitors and low and high pressure control as standard. Dual compressors are available on all standard efficiency models and 12.5 to 20 tons high efficiency models and allow for efficient cooling utilizing 3 stages of compressor operation (high efficiency models only). 25 tons high efficiency units have 3 compressors for up to 4 stages of compressor operation.

1. Each refrigerant circuit shall have service pressure ports, and refrigerant line filter driers factory installed as standard. An area shall be provided for replacement suction line driers.

E. Evaporator and Condenser Coils

1. Evaporator Coils (only on T/YS\*150, 180, 210, 240, 300G models)- Microchannel evaporator coils will be burst tested by the manufacturer. Internally finned, 5/16" copper tubes mechanically bonded to a configured aluminum plate fin shall be standard for evaporator coils. Coils shall be leak tested to ensure the pressure integrity. The evaporator coil shall be leak tested to 225 psig and pressure tested to 450 psig. Condenser Coils (available on T/Y\*\*150, 180, 210, 240, 300G models) - Microchannel condenser coils shall be standard on all units. Coils shall be leak tested to ensure the pressure integrity. The condenser coil shall be leak tested to 225 psig and pressure tested to 450 psig.

F. Electric Heating Section

1. The heating section shall be a factory-installed, ETL-listed electric resistance heat assembly. Heating elements shall be of the open-coil type, constructed of nickel-chromium alloy and supported in ceramic insulators. The assembly shall be mounted in a corrosion-resistant cabinet and positioned in the supply airstream to provide uniform air temperature. The electric heater shall include integral high-temperature limit controls with automatic reset primary limits and manual reset backup limits.
2. The electric heat system shall be staged and controlled through the unit's factory-mounted microprocessor control system. Heating stages shall be energized in sequence to maintain space temperature control and minimize electrical demand. The supply fan shall be proven operational prior to energizing any stage of electric heat, using a fan status interlock or airflow proving device. Loss of airflow during operation shall immediately de-energize all heating elements.
3. The unit controls shall provide safe and reliable operation with built-in protection against overheating and electrical faults. In the event of an abnormal condition, such as high temperature limit trip or airflow failure, the affected heating stage(s) shall be de-energized and locked out as required until the condition is cleared and the safety device is reset. The electric heat assembly shall be suitable for operation with the unit's specified power supply and shall comply with all applicable UL, NEC, and local code requirements.

G. Condenser Coil

1. The microchannel type condenser coil is standard for the standard efficiency models. Due to flat streamlined tubes with small ports, and metallurgical tube-to-fin bond, microchannel coil has better heat transfer performance. Microchannel condenser coil can reduce system refrigerant charge by up to 50% because of smaller internal volume, which leads to better compressor reliability. Compact all-aluminum microchannel coils also help to re-

duce the unit weight. All-aluminum construction improves re-cyclability. Galvanic corrosion is also minimized due to all aluminum construction. Strong aluminum brazed structure provides better fin protection. In addition, flat streamlined tubes also make micro-channel coils more dust resistant and easier to clean. Coils shall be leak tested at the factory to ensure the pressure integrity. The evaporator coil and condenser coil shall be leak tested to 600 psig. The assembled unit shall be leak tested to 465 psig.

H. Outdoor Fans

1. The outdoor fan shall be direct-drive, statically and dynamically balanced, draw-through in the vertical discharge position. The fan motor(s) shall be permanently lubricated and shall have built-in thermal overload protection.

I. Indoor Fan

1. Indoor fan shall be direct-drive plenum type with variable speed motor. All motors shall be thermally protected. All indoor fan motors meet the U.S. Energy Policy Act of 1992 (EPACT).

J. Variable Frequency Drive

1. Variable Frequency Drives shall be factory installed and tested to provide supply fan motor speed Modulation.

K. Controls

1. Unit shall be completely factory wired with necessary controls and contactor pressure lugs or terminal block for power wiring. Unit shall provide an external location for mounting a fused disconnect device. Unit controls shall be provided for all 24 volt control functions. The resident control algorithms shall make all heating, cooling, and/or ventilating decisions in response to electronic signals from sensors measuring indoor and outdoor temperatures. The control algorithm maintains accurate temperature control, minimizes drift from set point, and provides better building comfort. A centralized control shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.
2. Unit shall be provided with factory-mounted digital controls capable of BACnet communication with the BAS.

L. Discharge Line Thermostat

1. A bi-metal element discharge line thermostat is installed as a standard option on the discharge line of each system. This standard option provides extra protection to the compressors against high discharge temperatures in case of loss of charge, extremely high ambient and other conditions which could drive the discharge temperature higher. Discharge line thermostat is wired in series with high pressure control. When the discharge temperature rises above the protection limit, the bi-metal disc in the thermostat switches to the off position, opening the 24 VAC circuit. When the temperature on the discharge line cools down, the bi-metal disc closes the contactor circuit, providing power to the compressor. When the thermostat opens the fourth time, the unit control must be manually reset to resume operation on that stage.

M. Tool-less Hail Guards

1. Tool-less, hail protection quality coil guards are available for condenser coil protection.

N. Hinged Access Doors

1. Hinged sheet metal access doors shall be provided for the filter/evaporator section and the compressor/control section to allow convenient service access. Hinges shall be factory-installed and integral to the door assembly.

O. Economizer

1. Economizer shall be low-leak type meeting ASHRAE 90.1 leakage requirements.

P. Reference Enthalpy

1. Reference Enthalpy is used to measure and communicate outdoor humidity. The unit receives and uses this information to provide improved comfort cooling while using the economizer. Comparative Enthalpy measures and communicates humidity for both outdoor and return air conditions and return air temperature. The unit receives and uses this information to maximize use of economizer cooling, and to provide maximum occupant comfort control.

Q. Comparative Enthalpy

1. This option will be factory installed to measure and communicate humidity for both outdoor and return air conditions and return air temperature. The unit will receive and use this information to maximize use of economizer cooling, and to provide maximum occupant comfort control.

R. Accessory - Roof Curb

1. Provide roof curb height in accordance with code, roofing requirements, and equipment manufacturer instructions. Curb height shall be sufficient to maintain required duct clearances above the roof assembly and to accommodate duct routing as indicated on the drawings.
2. The roof curb shall be designed to mate with the unit and provide support and a water-tight installation when installed properly. The roof curb design shall allow field-fabricated rectangular supply/return ductwork to be connected directly to the curb. Curb design shall comply with NRCA requirements. Curb shall be shipped knocked down for field assembly and shall include wood nailer strips.

S. Sequence of Operation

1. See drawings.

## 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 RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting:
  - 1. Install RTUs 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 devices specified in Section 230548.13 "Vibration Controls for HVAC."

### 3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Gas Piping: Comply with applicable requirements in Section 231126 "Facility Liquefied-Petroleum Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

### 3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
  - 4. Install return-air duct continuously through roof structure.

### 3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical 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.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
  - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
  - 3. Locate nameplate where easily visible.

### 3.6 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."

### 3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
  - 1. Inspect for visible damage to unit casing.
  - 2. Inspect for visible damage to furnace combustion chamber.
  - 3. Inspect for visible damage to compressor, coils, and fans.
  - 4. Inspect internal insulation.
  - 5. Verify that labels are clearly visible.
  - 6. Verify that clearances have been provided for servicing.
  - 7. Verify that controls are connected and operable.
  - 8. Verify that filters are installed.

9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Inspect operation of barometric relief dampers.
14. Verify lubrication on fan and motor bearings.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.
  - a. Start refrigeration system.
  - b. Do not operate below recommended low-ambient temperature.
  - c. Complete startup sheets and attach copy with Contractor's startup report.
18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
  - a. Measure gas pressure on manifold.
  - b. Inspect operation of power vents.
  - c. Measure combustion-air temperature at inlet to combustion chamber.
  - d. Measure flue-gas temperature at furnace discharge.
  - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
  - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
  - a. Coil leaving-air, dry- and wet-bulb temperatures.
  - b. Coil entering-air, dry- and wet-bulb temperatures.
  - c. Outdoor-air, dry-bulb temperature.
  - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
  - a. Supply-air volume.
  - b. Return-air volume.
  - c. Relief-air volume.
  - d. Outdoor-air intake volume.
27. Simulate maximum cooling demand and inspect the following:
  - a. Compressor refrigerant suction and hot-gas pressures.
  - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
  - a. High-temperature limit on gas-fired heat exchanger.
  - b. Low-temperature safety operation.
  - c. Filter high-pressure differential alarm.
  - d. Economizer to minimum outdoor-air changeover.
  - e. Relief-air fan operation.
  - f. Smoke and firestat alarms.
29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

### 3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

### 3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems and after completing startup service, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

### 3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  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.

- E. RTU will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.13

SECTION 23 81 23 – LARGE CAPACITY COMPUTER-ROOM AIR-CONDITIONERS, WALL MOUNTED

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 floor-mounted, computer-room air conditioners.

1.3 DEFINITIONS

- A. COP: Coefficient of performance.
- B. EER: Energy efficiency ratio.
- C. SCR: Silicon controlled rectifier.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For computer-room air conditioners.
  - 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.
- C. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

- B. Seismic Qualification Data: Certificates, for computer-room air conditioners, 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.
- D. Sample Warranty: For special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fan Belts: 3 sets for each belt-driven fan.
  - 2. Filters: 3 sets of filters for each unit.

#### 1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
  - 2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
  - 3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. PETRA.
- B. Schneider Electrical.
- C. Leibert.

- D. Marvair (Basis of Design).

## 2.2 SUMMARY

- A. The environmental control system shall be designed specifically for temperature control applications. It shall automatically monitor and control cooling, heating as well as filtering functions for the conditioned space. The system shall be wall mounted and configured for front discharge of conditioned airflow with either front return airflow. The draw through air pattern shall provide uniform air distribution over the entire face of the cooling coil.

## 2.3 SUBMITTAL

- A. Submittals are provided with the proposal and shall include the following: capacity data, electrical data, physical data, and electrical and mechanical piping connections.

## 2.4 CABINET AND FRAME CONSTRUCTION

- A. The structure of the unit shall be characterized by a metal framework and internal parts made from hot zinc plated sheet steel.
- B. These profiles are connected by structural rivets designed to ensure sturdy assembly and which are capable of withstanding severe transportation and handling conditions. The units are also equipped with internal panels for shutting off the compartments affected by airflow; these internal panels are made from hot zinc plated sheet metal and ensure the following:
  - 1. Reduction in the noise transmitted through the paneling
  - 2. Air tightness even without external panels so that the units can also operate with the doors open during servicing
  - 3. The possibility of inspecting the internal elements without interfering with the operation of the unit and, more importantly, with the unit in operation C. The external panels shall be 1-mm thick, coated on the external side with RAL 9003 epoxy-polyester paint, which guarantees long-term durability. The front panels are attached to the framework by means of rapid coupling fasteners. The external panels are double-walled, lined with fiberglass heat-insulating material 15 mm (0.59 in.) in thickness and 20 kg/m<sup>3</sup> (.00073 lbs/in.<sup>3</sup>) of density.

## 2.5 RETURN AIR FILTERS

- A. The standard return air filters shall be MERV 8 per ASHRAE Standard 52.2.
  - 1. Return air filter shall be 2-in., deep, pleated, and replaceable from the front of the unit.

## 2.6 FAN/BLOWER

- A. Electronically Commutated Fans

1. Shall be plug/type, single inlet, and are dynamically balanced. The drive package is direct drive, electronically commutated (EC), and variable speed. The fans shall be located to draw air over the coil to ensure even air distribution and maximum coil performance.

## 2.7 CONTROLLER

- A. The unit shall be provided with a factory-mounted integral controller to manage all unit operations, including cooling, heating, and safety functions.
- B. The controller shall include a local user interface with display and keypad, or equivalent, to allow adjustment of setpoints, viewing of operating status, and indication of alarms.
- C. The unit shall be capable of interfacing with the building automation system (BAS) as indicated on the drawings.
- D. A remote wall-mounted control interface or thermostat shall be provided to allow temperature adjustment and unit control from within the conditioned space.
- E. Setpoints
  1. Stand-by Rotation Alarms: This screen shall be displayed if the local network is configured and is used to manage the start-up of the stand-by unit when an alarm is activated.
  2. Manual Control: Shall assist maintenance and checks or in cases of emergency; the following individual components can be activated manually and independently of the control process:
    - a. Unit Fan (Unit Start-up)
    - b. Compressor(s) 1/2/3/4
    - c. Dehumidification Function
    - d. 1st Stage Electrical Heater
    - e. 2nd Stage Electrical Heater
    - f. Activate 0/1 analog output. The safety devices shall be active during manual operation.
    - g. Alarms/Events
  3. Event Log: Shall save status information and a message with a date and time stamp for each alarm, event, or system configuration change.
  4. Syslog: Shall be used to export event logs from the unit to a connected server.
  5. Description of Alarm Events: Shall be displayed on the user interface (LCD touch screen Display).
    - a. High/Low Temperature Threshold Exceeded
    - b. High/Low Humidity Threshold Exceeded
    - c. Supply Air Temperature Threshold Exceeded
    - d. Return Air Sensor Error Detected
    - e. High/Low Airflow
    - f. Humidifier
    - g. Smoke/Fire Detected
    - h. Electric Heater Over Temperature
    - i. Electronic Expansion Valve Error
    - j. High/Low Refrigerant Pressure
    - k. Primary/Secondary Power Source Unavailable

- l. Dual Circuit Expansion Board Error Detected
- m. Digital 2/4/6 Input
- n. Supply Air Sensor Error Detected
- o. Air Filter Clogged
- p. Water Detected
- q. Humidity Sensor Error Detected
- r. Hot Water Sensor Error Detected
- s. EEPROM Error Detected
- t. Wrong Password Error

## 2.8 SCROLL COMPRESSOR(S)

- A. The systems shall utilize hermetic scroll compressors. The compressors shall be mounted with anti-vibration support inside a dedicated mechanical space, which shall be separated from the air flow of the system to ensure ease of maintenance inspection during operation.

- 1. Compressor shall have the following standard features:

- a. Crankcase Heaters (Factory Mounted)
- b. Integrated Overheat Protection
- c. High Pressure Switch Protection

## 2.9 REFRIGERANT

- A. The refrigeration system shall be designed to use R-454B.

## 2.10 ELECTRONIC EXPANSION VALVE (EEV)

- A. Direct Expansion (DX) systems shall have electronic expansion valves.

## 2.11 EVAPORATOR COIL

- A. The evaporator coil shall be designed with a large front surface area in order to have an elevated SHR and a low air-velocity speed to prevent condensation carryover issues. The evaporator coil shall be made from copper tubes mechanically expanded on aluminum fins, complete with a hydrophilic coating to reduce the surface tension between the water and the metal fin surface promoting sheeting of the condensation and avoiding the risk of condensation carryover.
- B. The evaporator coil shall be built with two circuits, which are linked together to maximize the surface area of the coil regardless of which circuit is operating.
- C. The evaporator condensate drain pan shall be constructed of stainless steel.

## 2.12 AIR COOLED

- A. Air-Cooled Systems

1. The indoor unit shall consist of an evaporator section including evaporator coil, blower package, controls, electrical section, and refrigerant piping internal to the evaporator coil and compressor will be sealed with a positive pressure of dry nitrogen.
2. Refrigerant piping required for interconnecting the evaporator and condenser sections shall be field supplied and installed to include the refrigerant R-410A required to charge the system.

B. Self-contained packaged unit

1. The unit shall be a factory-packaged, self-contained system requiring no field-installed refrigerant piping.

C. Low Ambient Kits

1. Air-cooled condensers with optional low ambient kit shall be designed for lowest allowable ambient temperature -30°F.
2. Shall consist of either 8.1 kg (18 lbs), 11.7 kg (26 lbs) or 27 kg (60 lbs) receiver based on the condenser refrigerant volume. Shall have a fusible plug, head pressure control valve, check valve, rotalock valves, heater with thermostat, wire harness, and fully insulated.

2.13 OPTIONAL COMPONENTS

A. Heating Options

1. Electric Heat
  - a. Shall consist of aluminum finned heating elements, complete with manual reset over temperature thermostat to cut off the power supply to the heater and activate an alarm in the event of overheating.
2. Hot Gas Heat (not available for models 2242, 2542, and 3342)
  - a. Air-cooled systems shall be supplied with a factory installed copper tube and aluminum fin hot gas heat coil.
  - b. The coil shall consist of a factory piped and wired 3-way heat reclaim regulator, check valve and controlled by the microprocessor.
3. The "Heat Option" has two functions:
  - a. Heating the air to bring it up to the room set point
  - b. Reheating during the dehumidification phase, to bring the temperature of the air to the room setpoint. The installed heating capacity is therefore capable of maintaining the dry bulb temperature in the room during operation in dehumidifier mode.

B. Water Detection Options (Tape or Spot)

1. Tape Water Leak Detection Sensor: Shall include a control module to be installed inside the electrical panel and an external water sensor to be field installed. The maximum wiring distance is 500 m (1640 ft). The water detector sensors can be configured to stop the unit from running upon activating a water detection alarm.
2. Spot Water Detection Sensor: Shall include a control module to be installed inside the electrical panel and an external water sensor to be field installed. The maximum wiring

distance is 500 m (1640 ft). The water detector sensors can be configured to stop the unit from running upon activating a water detection alarm.

C. Smoke Detector / Firestat Factory Installed

1. Smoke/Firestat Option: Shall have a Smoke and Fire Sensor comprising a control module to be installed inside the electrical panel and an external sensor. The smoke/fire stat shuts the unit down and provides a visual and audible alarm at the user interface (LCD touch screen display).
2. Remote Fire and Smoke Relay - Shall provide a 24V relay for external connection of the smoke or fire sensor. The fire stat shuts the unit down and provides a visual and audible alarm at the user interface (LCD touch screen display).

D. Communication Options

1. TCP/IP serial adapter: This field-installed serial adapter card shall plug directly into the microprocessor and allow communication between the microprocessor and the customer network or supervision system via a single Ethernet connection in BACNet IP (pCoWeb), SNMP, Modbus IP, and TCP/IP simultaneously.
2. RS485 serial adapter: Field-installed serial adapter card that shall plug directly into the microprocessor to allow communication via an RS485 connection between the microprocessor and the supervision system of the customer using modbus RTU or Johnson Controls Metasys protocol.
3. LON serial adapter: Field-installed serial adapter card that shall plug directly into the microprocessor to allow communication between the microprocessor and the LON supervision system of the customer.
4. RS232 serial adapter: This is a field installed serial adapter card that shall plug directly into the microprocessor to allow communication between the microprocessor and a supervision system modem via an RS232 connection.

## 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 hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

- B. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.
- C. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads elastomeric mounts restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC." Section 23 05 48.13 "Vibration Controls for HVAC."
  - 1. Minimum Deflection: 1 inch.
- D. Air-Cooled Refrigerant Condenser Mounting: Install using restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC." Section 23 05 48.13 "Vibration Controls for HVAC."
  - 1. Minimum Deflection: 1 inch.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners allow space for service and maintenance.
- C. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00 "Refrigerant Piping." Provide shutoff valves and piping.

### 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 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. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
  - 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. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

- F. After startup service and performance test, change filters and flush humidifier.

### 3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. 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.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 23 81 23

## SECTION 23 82 39 - UNIT HEATERS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes
  - 1. Cabinet unit heaters.
  - 2. Wall heaters.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and 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 details of anchorages and attachments to structure and to supported equipment.
  - 4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
  - 5. Wiring Diagrams: Power, signal, and control wiring.

#### 1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 CABINET UNIT HEATERS

- A. MANUFACTURERS
  - 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. Carrier Global Corporation.
    - b. INDEECO.
    - c. Marley Engineered Products (Basis of Design)

B. GENERAL

1. Heaters: Factory-assembled and -tested unit complying with AHRI 440.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with UL 2021.

C. PERFORMANCE REQUIREMENTS

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. CABINETS

1. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

E. CONTROLS

1. Fan and Motor Board: Removable.
  - a. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230500 "Common Work Results for HVAC."
  - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
2. Basic Unit Controls:
  - a. Control voltage transformer.
  - b. Unit-mounted temperature sensor.
  - c. Data entry and access port.
    - 1) Input data includes room temperature and occupied and unoccupied periods.
    - 2) Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
3. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.2 WALL UNIT HEATERS

A. MANUFACTURERS

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

- b. INDEECO.
- c. Marley Engineered Products.
- d. Quellet Canada Inc.
- e. QMark; Marley Engineered Products.
- f. Raywall (Basis of Design).

B. DESCRIPTION

- 1. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. CABINET

- 1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.
- 2. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- 4. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

D. COIL

- 1. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

E. FAN AND MOTOR

- 1. Fan: Aluminum propeller directly connected to motor.
- 2. Motor: Permanently lubricated. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

F. CONTROLS

- 1. Controls: Unit-mounted thermostat.
- 2. Electrical Connection: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install unit heaters to comply with NFPA 90A.
- B. Install unit heaters level and plumb.

END OF SECTION 23 82 39

## SECTION 26 05 19 - 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. Connectors, splices, and terminations rated 600 V and less.
- B. Related Requirements:
  - 1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

#### 1.3 DEFINITIONS

- A. PV: Photovoltaic.
- B. RoHS: Restriction of Hazardous Substances.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency
- B. Field quality-control reports.

#### 1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or NICET.
  - 1. Testing Agency's Field Supervisor: Certified by NETA or NICET to supervise on-site testing.

## PART 2 - PRODUCTS

### 2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Alpha Wire Company.
  - 2. American Bare Conductor.
  - 3. Belden Inc.
  - 4. Cerro Wire LLC.
  - 5. Encore Wire Corporation.
  - 6. General Cable Technologies Corporation.
  - 7. Okonite Company (The).
  - 8. Service Wire Co.
  - 9. Southwire Company.
  - 10. WESCO.
- 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.

### 2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. 3M Electrical Products.
  - 2. AFC Cable Systems; a part of Atkore International.
  - 3. Gardner Bender.
  - 4. Hubbell Power Systems, Inc.
  - 5. Ideal Industries, Inc.
  - 6. ILSCO.
  - 7. NSi Industries LLC.
  - 8. O-Z/Gedney; a brand of Emerson Industrial Automation.
  - 9. Service Wire Co.
  - 10. TE Connectivity Ltd.
  - 11. Thomas & Betts Corporation; A Member of the ABB Group.

- 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. Material: Copper
  - 2. Type: One hole with standard barrels.
  - 3. Termination: Compression.

### PART 3 - EXECUTION

#### 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper for feeders smaller than No. 4 AWG; copper for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.
- E. PV Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

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

- A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, and Partitions,: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.
- E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.
- F. Exposed Branch Circuits,: Type THHN/THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.
- H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in liquid tight raceway/ flexible metal.

- J. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway Metal-clad cable, Type MC. Type MC cable not allowed in the COPS areas.
- K. Cord Drops and Portable Appliance Connections: Type SO/SJO , hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls and ceilings, 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. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

### 3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

### 3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

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

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

### 3.7 FIRESTOPPING

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

### 3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
- 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 NETA or NICET requirements.

END OF SECTION 26 05 19

## SECTION 26 05 23 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Backboards.
  - 2. Category 6 balanced twisted pair cable.
  - 3. Low-voltage control cabling.
  - 4. Control-circuit conductors.
  - 5. Identification products.

#### 1.2 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. 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.
- C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- D. RCDD: Registered Communications Distribution Designer.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency, RCDD, layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

#### 1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA or NICET.

### 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. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
  - 1. Flame Travel Distance: 60 inches or less.
  - 2. Peak Optical Smoke Density: 0.5 or less.
  - 3. Average Optical Smoke Density: 0.15 or less.
- C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.
- E. RoHS compliant.

## 2.2 BACKBOARDS

- A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches."
- B. Painting: Paint plywood on all sides and edges with flat eggshell black latex alkyd paint. Comply with requirements in Section 099120 "Interior Painting."

## 2.3 LOW-VOLTAGE CONTROL CABLE

- A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
  - 1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
  - 2. PVC insulation.
  - 3. Unshielded.
  - 4. PVC jacket.
  - 5. Flame Resistance: Comply with NFPA 262.

## 2.4 CONTROL-CIRCUIT CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Encore Wire Corporation.
  - 2. General Cable; General Cable Corporation.
  - 3. Service Wire Co.
  - 4. Southwire Company.
- B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.
- C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

- D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.
- E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
  - 1. Smoke control signaling and control circuits.
  - 2. SOURCE QUALITY CONTROL
- F. Factory test twisted pair cables according to TIA-568-C.2.
- G. Cable will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Test cables on receipt at Project site.
  - 1. Test each pair of twisted pair cable for open and short circuits.

#### 3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
  - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
  - 2. Flexible metal conduit shall not be used.
- B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- C. Install manufactured conduit sweeps and long-radius elbows if possible.
- D. Raceway Installation in Equipment Rooms:
  - 1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
  - 2. Install cable trays to route cables if conduits cannot be located in these positions.
  - 3. Secure conduits to backboard if entering the room from overhead.
  - 4. Extend conduits 3 inches above finished floor.
  - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

- E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.

- B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; 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 and shall be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

- C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

- D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.
2. Use insulated spade lugs for wire and cable connection to screw terminals.
3. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 72 inches of cable in a coil not less than 12 inches in diameter.

G. Separation from EMI Sources:

1. Comply with BICSI TDM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
  - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches.
  - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches.
  - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
  - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
  - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches.
  - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches.
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 or Circuit Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches.
  - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

### 3.4 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

### 3.5 CONTROL-CIRCUIT CONDUCTORS

- A. Minimum Conductor Sizes:
  - 1. Class 1 remote-control and signal circuits; No 14 AWG.
  - 2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
  - 3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

### 3.6 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

### 3.7 GROUNDING

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.8 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.
- C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

### 3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
  - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 26 05 23

## SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Ground bonding common with lightning protection system.
  - 3. Foundation steel electrodes.
  - 4. Computer facilities signal reference grounding system.

#### 1.2 ACTION SUBMITTALS

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

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
  - 1. Test wells.
  - 2. Ground rods.
  - 3. Ground rings.
  - 4. Grounding arrangements and connections for separately derived systems.
  - 5. Signal Reference Grounding.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

#### 1.4 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 018300 "Operation and Maintenance Data," include the following:
    - a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
      - 1) Test wells.
      - 2) Ground rods.
      - 3) Ground rings.
      - 4) Grounding arrangements and connections for separately derived systems.

## 1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA or NICET.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

### 2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Lightning Technology, Ltd.
  - 2. Burndy; Part of Hubbell Electrical Systems.
  - 3. Dossert; AFL Telecommunications LLC.
  - 4. ERICO International Corporation.
  - 5. Fushi Copperweld Inc.
  - 6. Galvan Industries, Inc.; Electrical Products Division, LLC.
  - 7. Harger Lightning & Grounding.
  - 8. ILSCO.
  - 9. O-Z/Gedney; a brand of Emerson Industrial Automation.
  - 10. Robbins Lightning, Inc.
  - 11. SIEMENS Industry, Inc.; Energy Management Division.
  - 12. Thomas & Betts Corporation; A Member of the ABB Group.

### 2.3 CONDUCTORS

- A. Insulated Conductors: 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 B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
  - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
  - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

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

## 2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Ground Rod Connections: Exothermically welded.
- K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- N. Signal Referenced Grid: Exothermically welded.
- O. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.
- P. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- Q. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- R. Water Pipe Clamps:
  - 1. Mechanical type, two pieces with stainless-steel bolts.
    - a. Material: Tin-plated aluminum Die-cast zinc alloy.

- b. Listed for direct burial.
- 2. U-bolt type with malleable-iron clamp and copper ground connector.

## 2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
  - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
  - 2. Backfill Material: Electrode manufacturer's recommended material.
- C. Ground Plates: 1/4 inch thick, hot-dip galvanized.
- D. Uifer Grounding System: Concrete encased grounding electrode in accordance with NEC 250 (A) (3), of 20 feet minimum length.

## 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 barecopper conductor, No. 2/0 AWG minimum.
  - 1. Bury at least 24 inches below grade.
  - 2. Duct-Bank Grounding Conductor: Bury 12 inches above ductbank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
  - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
  - 2. 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.
- E. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors.

4. Connections to Structural Steel: Welded connectors.

### 3.2 GROUNDING AT THE SERVICE

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

### 3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: 3/4" by 10'-0' Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

### 3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
  1. Feeders and branch circuits.
  2. Lighting circuits.
  3. Receptacle circuits.
  4. Single-phase motor and appliance branch circuits.
  5. Three-phase motor and appliance branch circuits.
  6. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, 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.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

- G. Poles Supporting Outdoor Lighting Fixtures: Install a  $\frac{3}{4}$ " by 10'-0" grounding electrode and a separate insulated equipment grounding conductor for each pole in addition to grounding conductor installed with branch-circuit conductors.

### 3.5 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 12 inches below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  2. Use exothermic welds for all below-grade connections except for grounding test well connection which shall be provided with two (2) bolt connections.
  3. For grounding electrode system, install at least three rods spaced at least 20'-0" 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 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- 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 ground-

- ing 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. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
  - 1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
  - 2. Bury ground ring not less than 24 inches from building's foundation.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
  - 1. If concrete foundation is less than 20 feet 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.
- K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.
- L. 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.

### 3.6 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
  - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
  - b. Perform tests by fall-of-potential method according to IEEE 81.
4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

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

D. Prepare test and inspection reports.

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

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
4. Substations and Pad-Mounted Equipment: 5 ohms.
5. Manhole Grounds: 10 ohms.
6. ohms.

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

END OF SECTION 26 05 26

## SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

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

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

### 1.3 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.
- C. Welding certificates.

### 1.4 QUALITY ASSURANCE

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

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
  2. Component Importance Factor: 1.5.
  3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - 1. Flame Rating: Class 1.
  - 2. Self-extinguishing according to ASTM D 635.

## 2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
  - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
  - 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
  - 3. Channel Width: Selected for applicable load criteria.
  - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  - 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
  - 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
  - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
  - 2. Channel Material: 6063-T5 aluminum alloy.
  - 3. Fittings and Accessories Material: 5052-H32 aluminum alloy.
  - 4. Channel Width: Selected for applicable load criteria.
  - 5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
  - 6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. 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.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

## 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
  1. NECA 1.
  2. NECA 101
  3. NECA 102.
  4. NECA 105.
  5. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

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

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by and fastened to openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  1. To Wood: Fasten with lag screws or through bolts.
  2. To New Concrete: Bolt to concrete inserts.
  3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  4. To Existing Concrete: Expansion anchor fasteners.
  5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
  7. To Light Steel: Sheet metal screws.
  8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

### 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 4000-psi, 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: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

## SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

#### 1.2 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.
- D. EMT: Electrical Metallic Tubing.
- E. LFMC: Liquid Tight Flexible Metallic Raceway (Sealtite).

#### 1.3 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.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- D. Source quality-control reports.

## PART 2 - PRODUCTS

### 2.1 METAL CONDUITS AND FITTINGS

- A. Metal Conduit:
  1. 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 rigid steel conduit.
    - a. Comply with NEMA RN 1.
    - b. Coating Thickness: 0.040 inch, 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. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
  5. Fittings for EMT:
    - a. Material: Steel.
    - b. Type: compression, insulated threat.

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

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R Type 4 unless otherwise indicated, and sized according to NFPA 70.
  - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. 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.
- C. Wireway Covers: Hinged type unless otherwise indicated.
- D. Finish: Manufacturer's standard enamel finish.

## 2.3 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.
- D. Metal Floor Boxes:
  - 1. Material: Cast metal.
  - 2. Type: Fully adjustable.
  - 3. Shape: Rectangular.
  - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum galvanized, cast iron with gasketed cover.

- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Gangable boxes are allowed.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4 and Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures: Plastic Fiberglass.
  - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
  - 1. NEMA 250, Type 1, Type 3R and Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Accessory feet where required for freestanding equipment.
  - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.4 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. Handholes used for Duke Energy Cable is to be approved by Duke Energy.
- 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. Standard: Comply with SCTE 77.
  - 2. Configuration: Designed for flush burial with open closed integral closed bottom unless otherwise indicated.
  - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
  - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  - 5. Cover Legend: Molded lettering, "ELECTRIC." or "Telecom"
  - 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
  - 7. Handholes 12 Inches Wide by 24 Inches Long and Larger: Provide inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

1. Standard: Comply with SCTE 77.
2. Color of Frame and Cover: Gray.
3. Configuration: Designed for flush burial with open closed integral closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC."
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

## 2.5 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. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC and IMC.
  2. Concealed Conduit, Aboveground: GRC and IMC.
  3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
  4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R, or Type 4X.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
    - a. Not acceptable in COP areas, use IMC or GRS
  2. Exposed, Not Subject to Severe Physical Damage: EMT.
    - a. Not acceptable in COP areas, use IMC or GRS
  3. Exposed and Subject to Severe Physical Damage: GRC and IMC. Raceway locations include the following:
    - a. Mechanical rooms.
    - b. COP area
  4. Concealed in Ceilings and Interior Walls and Partitions: EMT.

- a. Not acceptable in DCOA. use IMC or GRS
- 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 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: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  - 2. 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 compression, insulated throat 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. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- G. Install surface raceways only where indicated on Drawings.
- H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

### 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 "explosion-relief" walls or rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Complete raceway installation before starting conductor installation.
- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of all changes in direction.
- I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches of enclosures to which attached.
- L. Raceways Embedded in Slabs:
  - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 5-foot intervals.
  - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - 3. Arrange raceways to keep a minimum of 1 inch of concrete cover in all directions.
  - 4. 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. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- S. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

- T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- V. Expansion-Joint Fittings:
  - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
  - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    - d. Attics: 135 deg F temperature change.
  - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
  - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- W. 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.
- X. 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.
- Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- Z. Locate boxes so that cover or plate will not span different building finishes.
- 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.

### 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 310000 is "Earthwork" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 310000 is "Earthwork"
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 310000 is "Earthwork".
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
  - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

### 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install 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.

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

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

### 3.6 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 26 05 33

## SECTION 26 05 36 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Wire-mesh cable tray.
2. Cable tray accessories.
3. Warning signs.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
  - a. Vertical and horizontal offsets and transitions.
  - b. Clearances for access above and to sides of cable trays.
  - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
  - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and 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.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Contractors shall provide coordinated floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Scaled cable tray layout for each cable tray system in ceilings and below raised floors 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 below the raised floor assembly and below bottom of ceiling structure.
- B. Field quality-control reports.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
  2. Component Importance Factor: 1.0.
- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

### 2.2 GENERAL REQUIREMENTS FOR CABLE TRAY

- 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. Structural Performance: See articles on 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-MESH CABLE TRAY

- A. Description:
1. Configuration: Manufactured Galvanized- steel wire mesh, complying with NEMA VE 1.
  2. Width: 24 inches unless otherwise indicated on Drawings.
  3. Minimum Usable Load Depth: 6 inches.
  4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.

5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
6. Splicing Assemblies: Bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

B. Materials and Finishes:

1. Steel:
  - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
  - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
  - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
  - d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.

2.4 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.

2.5 WARNING SIGNS

- A. Lettering: 1-1/2-inch-high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Comply with Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable tray and support systems according to NEMA FG 1.
- B. Install cable tray 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 tray, 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. Fasten cable tray supports to building structure.
- F. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."
- G. 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 tray.
- H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in two threaded stem trapeze or wall-bracket form as required by application.
- I. Support assembly to prevent twisting from eccentric loading.
- J. Do not install more than one cable tray splice between supports.
- K. 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.
- L. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.
- M. Make changes in direction and elevation using manufacturer's recommended fittings.
- N. Make cable tray connections using manufacturer's recommended fittings.
- O. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
- P. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- Q. Install cable trays with enough workspace to permit access for installing cables.
- R. 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.
- S. Install permanent covers and cover clamps, if used, after installing cable.
- T. 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 electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
- D. 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. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18 inches.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.
- E. Tie mineral-insulated cables down every 36 inches where required to provide a two-hour fire rating and every 72 inches elsewhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

### 3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect raceways 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:
  - 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
  - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.

3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

### 3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 26 05 36

## 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. Flexible nonmetallic duct.
  - 4. Duct accessories.
  - 5. Precast concrete handholes.
  - 6. Polymer concrete handholes and boxes with polymer concrete cover.
  - 7. Fiberglass handholes and boxes with polymer concrete cover.
  - 8. Fiberglass handholes and boxes.
  - 9. High-density plastic boxes.
  - 10. Precast manholes.
  - 11. Cast-in-place manholes.
  - 12. 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, and other utility structures.
4. Include underground-line warning tape.
5. Include warning planks.

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. Qualification Data: For professional engineer and testing agency responsible for testing non-concrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C858.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

#### 1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

#### 1.8 FIELD CONDITIONS

- A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

### PART 2 - PRODUCTS

#### 2.1 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Arnco
  - 2. Beck
  - 3. Nation Pipe
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
- D. Solvents and Adhesives: As recommended by conduit manufacturer.

#### 2.2 DUCT ACCESSORIES

- A. 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.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

#### 2.3 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 Co
  - 2. Utility Concrete Products
  - 3. Rinker Group, Ltd
- C. Comply with ASTM C858 for design and manufacturing processes.
- D. Handholes used for electrical service to be approved by Duke Energy.
- E. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- F. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- G. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
  - 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- H. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
  - 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- I. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- J. Cover Legend: Molded lettering TELECOM or ELECTRIC as required.
- K. Configuration: Units shall be designed for flush burial and have closed bottom unless otherwise indicated.
- L. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
- M. 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.
- N. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
  - 1. Center window location.

2. Knockout panels shall be located no less than 6 inches 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 thick.
- O. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
  2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
- P. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

#### 2.4 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Old Castle
  2. Quazite
  3. Armorcast
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
- E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- G. Cover Legend: Molded lettering, "ELECTRIC" or "Telecom as required"
- H. 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.
- I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- J. Handholes shall have factory-installed inserts for cable racks and pulling-in irons.

- K. 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.

## 2.5 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. Rated H20 truckload.
    - 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: TELECOM or ELECTRIC
- C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.
  - 1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated 2500-lbf minimum tension.
- E. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch-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 shear and 60,000-lbf 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 ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
  - 1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- G. Ground Rod Sleeve: 3-inch PVC sleeve in manhole floors 2 inches 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 bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- I. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches in width by nominal 24 inches long; punched with 14 hook holes on 1-1/2-inch centers for cable-arm attachment.
  2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
  3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- J. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
1. Stanchions: Nominal 36 inches high by 4 inches 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 with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.
- K. 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. Capable of withstanding temperature of 300 deg F 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.
- L. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. required.

## 2.6 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. Tests of materials shall be performed by an independent testing agency.
  2. 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.
  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 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.

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical and Telecom: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- B. Stub-ups: Concrete-encased 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, Non-deliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
  - 3. 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 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 48 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.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. 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 o.c. for 4-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.
- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet 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."
- J. 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 hydrostatic pressure.
- K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.
- L. Concrete-Encased Ducts and Duct Bank:
  - 1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
  - 2. Width: Excavate trench 12 inches wider than duct on each side.
  - 3. Width: Excavate trench 3 inches wider than duct on each side.

4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct 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 of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. 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. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
  - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
  - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
  - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. 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.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. 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.
10. 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 of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
11. 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 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.

- a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
  - b. Place minimum 6 inches of engineered fill above concrete encasement of duct.
- N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.
- O. Underground-Line Warning Tape: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

### 3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

#### A. Cast-in-Place Manhole Installation:

- 1. Finish interior surfaces with a smooth-troweled finish.
- 2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
- 3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

#### B. 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 sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

#### C. Elevations:

- 1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
- 2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch 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 above finished grade.
- 5. Where indicated, cast handhole cover frame integrally with handhole structure.

#### D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

#### E. 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.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
- G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

### 3.6 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 sieve to No. 4 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 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.

### 3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.8 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-long mandrel equal to duct size minus 1/4 inch. 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.

### 3.9 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.

END OF SECTION 260543

## SECTION 26 05 44 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.
- B. Related Requirements:
  - 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

#### 1.3 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Wall Sleeves:
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
  - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

- D. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- E. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized sheet steel.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Advance Products & Systems, Inc.
    - b. CALPICO, Inc.
    - c. Metraflex Company (The).
    - d. Pipeline Seal and Insulator, Inc.
    - e. Proco Products, Inc.
  - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Carbon steel.
  - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. HOLDRITE.

## 2.4 GROUT

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

- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 05 44

## SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Restraints - rigid type.
3. Restraints - cable type.
4. Restraint accessories.
5. Post-Installed concrete anchors.
6. Concrete inserts.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

#### 1.2 DEFINITIONS

- A. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

#### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic- and wind-load-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-load-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 ICC-ES product listing.
4. Annotate to indicate application of each product submitted and compliance with requirements.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

- C. Delegated Design Submittal for Each Seismic-Restraint Device: Signed and sealed by qualified structural professional engineer.
  - 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.
    - c. Seismic Design Calculations: Submit input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
    - d. Refer to structural drawing S-001 for wind and seismic load information.
- D. Delegated Design Submittal for Each Wind-Load Protection Device: Signed and sealed by qualified structural professional engineer.
  - 1. For each wind-load protection 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. Wind-Load Restraint: Select wind-load restraints complying with performance requirements, design criteria, and analysis data.
    - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind loads. Include certification that device is approved by an NRTL for reinforcement use.
    - c. Wind-Load Design Calculations: Submit static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
  - 2. Seismic- and Wind-Load-Restraint Detail Drawings: Signed and sealed by qualified structural professional engineer.
    - a. Design Analysis: To support selection and arrangement of seismic and wind-load 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 details required for equipment mounted outdoors.
  - 3. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES UL FM Approvals OSHPD an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- E. Refer to structural drawing S-001 for seismic and wind load information.

## PART 2 - PRODUCTS

### 2.1 ELASTOMERIC ISOLATION PADS

#### A. Elastomeric Isolation Pads: .

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. 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. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: Resilient and elastomeric.
  - a. Surface Pattern: Smooth, ribbed, or waffle pattern.
  - b. Infused nonwoven cotton or synthetic fibers.

### 2.2 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, 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.
- Seismic- and Wind-Load-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.
- #### B.
- Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

### 2.4 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.

## 2.5 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 for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:
  - 1. 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. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
- B. Comply with MSS SP-58.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic and wind-load control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

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

### 3.3 INSTALLATION OF SEISMIC-RESTRAINT AND WIND-LOAD CONTROL DEVICES

- A. Provide seismic restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load 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 and high wind events.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of seismic and wind-load restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment Restraints:
  - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
  - 2. Install seismic-restraint and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:
  - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
  - 2. Install seismic-restraint and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

3. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
  4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Post-Installed Concrete Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor 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. Field tests must be witnessed by authorities having jurisdiction.
- 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 no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
  5. Test to 90 percent of rated proof load of device.
- C. Nonconforming Work:
1. Seismic controls will be considered defective if they do not pass tests and inspections.
  2. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

END OF SECTION 260548

## 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 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

#### 1.2 DEFINITIONS

- A. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

#### 1.3 COORDINATION

A. Tests and Inspections:

1. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection 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.

#### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic- and wind-load-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-load-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 ICC-ES product listing.
  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.
    - c. Seismic Design Calculations: Submit input data and loading calculations prepared under Section 260011 "Facility Performance Requirements for Electrical."
    - d. Refer to structural drawings S-001 for wind and seismic load information.
- C. Delegated Design Submittal: Signed and sealed by qualified structural professional engineer, for each wind-load protection device.
1. For each wind-load protection 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. Wind-Load Restraint: Select wind-load restraints complying with performance requirements, design criteria, and analysis data.
    - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind loads. Include certification that device is approved by an NRTL for reinforcement use.
    - c. Wind-Load Design Calculations: Submit static and dynamic loading calculations prepared under Section 260011 "Facility Performance Requirements for Electrical."
  2. Seismic- and Wind-Load-Restraint Detail Drawings prepared by qualified structural professional engineer:
    - a. Design Analysis: To support selection and arrangement of seismic and wind-load 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 details required 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).

- D. Refer to structural drawing S-001 for wind and seismic load information.

## PART 2 - PRODUCTS

### 2.1 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, 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.

### 2.2 RESTRAINTS - CABLE TYPE

- A. Seismic- and Wind-Load-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.
- B. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

### 2.3 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.

### 2.4 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 for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. 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.

## 2.5 CONCRETE INSERTS

A. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.

B. Comply with MSS SP-58.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic and wind-load control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

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

### 3.3 INSTALLATION OF SEISMIC-RESTRAINT AND WIND-LOAD CONTROL DEVICES

- A. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load 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 and high wind events.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of seismic and wind-load restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment Restraints:
  - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
  - 2. Install seismic-restraint and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:
  - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
  - 2. Install seismic-restraint and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES 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 evaluation service member of ICC-ES 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. Field tests must be witnessed by authorities having jurisdiction.
- B. 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.
- C. Seismic controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 260548.16

## SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

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

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.

- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
  - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

## 2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage[ and system or service type].
- B. Warning Label Colors:
  - 1. Identify system voltage with black letters on an orange background.
- C. Warning labels and signs shall include, but are not limited to, the following legends:
  - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
  - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
- D. Equipment Identification Labels:
  - 1. Black letters on a white field.

## 2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester vinyl flexible label with acrylic pressure-sensitive adhesive.
  - 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
  1. Minimum Nominal Size:
    - a. 1-1/2 by 6 inches for raceway and conductors.
    - b. 3-1/2 by 5 inches for equipment.
    - c. As required by authorities having jurisdiction.

## 2.4 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

## 2.5 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
- C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and are 12 inches wide. Stop stripes at legends.
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- E. Underground-Line Warning Tape:
  1. Tape:
    - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  2. Color and Printing:
    - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.

- b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE" Insert inscription.
      - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
    - 3. Tag: Type I:
      - a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
      - b. Width: 3 inches.
      - c. Thickness: 4 mils.
      - d. Weight: 18.5 lb/1000 sq. ft..
      - e. Tensile according to ASTM D 882: 30 lbf and 2500 psi.
    - 4. Tag: Type II:
      - a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
      - b. Width: 3 inches.
      - c. Thickness: 12 mils.
      - d. Weight: 36.1 lb/1000 sq. ft..
      - e. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.
  - F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.
- 2.6 TAGS
- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
  - B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
    - 1. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment.
    - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- 2.7 SIGNS
- A. Baked-Enamel Signs:
    - 1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
    - 2. 1/4-inch grommets in corners for mounting.
    - 3. Nominal Size: 7 by 10 inches.
  - B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:
  - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
  - b. For signs larger than 20 sq. in., 1/8 inch thick.
  - c. Engraved legend with black letters on white face.
  - d. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

## 2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

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

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

## 2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

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

## PART 3 - EXECUTION

### 3.1 PREPARATION

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

### 3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
  - 1. Secure tight to surface of conductor, cable, or raceway.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- I. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
- J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- K. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
  - 1. "EMERGENCY POWER."
  - 2. "UPS POWER."
- L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
  2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- O. Self-Adhesive Labels:
1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
  2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- V. Underground Line Warning Tape:
1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
  2. Limit use of underground-line warning tape to direct-buried cables.
- W. Metal Tags:
1. Place in a location with high visibility and accessibility.
  2. Secure using general-purpose cable ties.
- X. Nonmetallic Preprinted Tags:

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

Y. Write-on Tags:

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

Z. Baked-Enamel Signs:

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

AA. Metal-Backed Butyrate Signs:

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

BB. Laminated Acrylic or Melamine Plastic Signs:

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

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

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

### 3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels vinyl tape applied in bands.
  1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- C. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
  2. "UPS POWER."
- D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels self-adhesive wraparound labels snap-around labels snap-around color-coding bands self-adhesive vinyl tape to identify the phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags with the conductor or cable designation, origin, and destination.
- F. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.
- G. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- H. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- I. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- J. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.
1. Apply to exterior of door, cover, or other access.
  2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
    - a. Power-transfer switches.
    - b. Controls with external control power connections.
- L. Arc Flash Warning Labeling: Self-adhesive labels.
- M. Operating Instruction Signs: Self-adhesive labels.
- N. Emergency Operating Instruction Signs: Self-adhesive labels with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
- O. Equipment Identification Labels:
1. Indoor Equipment: Self-adhesive label.

2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:
  - a. Panelboards: Typewritten directory of circuits in the location provided by panel-board manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
  - b. Enclosures and electrical cabinets.
  - c. Access doors and panels for concealed electrical items.
  - d. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
  - e. Emergency system boxes and enclosures.
  - f. Enclosed switches.
  - g. Enclosed circuit breakers.
  - h. Enclosed controllers.
  - i. Push-button stations.
  - j. Power-transfer equipment.
  - k. Remote-controlled switches, dimmer modules, and control devices.
  - l. Battery racks.
  - m. Power-generating units.
  - n. Monitoring and control equipment.
  - o. UPS equipment.
  - p. EPO Switches
  - q. Automatic Transfer Switches.
  - r. Manual Transfer Switches.

END OF SECTION 26 05 53

## SECTION 26 05 73 – POWER SYSTEM STUDY

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes computer-based power study of the electrical distribution system that includes:
  - 1. Overcurrent protection device study to determine overcurrent device setting.
  - 2. Fault-current study to determine rating of equipment and the minimum interrupting capacity of circuit protective devices.
  - 3. 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 which 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. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Coordination-study input data, including completed computer program input data sheets.
  - 2. 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 the 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 the selection of devices and associated characteristics is satisfactory.
4. Short-circuit study input data, including completed computer program input data sheets.
5. Short-circuit study and equipment evaluation report.
6. Arc-flash study input data, including completed computer program input data sheets.
7. Arc-flash study report.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Power Study Software Developer.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.
- C. Product Certificates: short-circuit study software, certifying compliance with IEEE 399.
- D. Product Certificates: arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
  1. Include the following:
    - a. The following parts from the Protective Device Coordination Study Report:
      - 1) One-line diagram
      - 2) Protective device coordination study
      - 3) Time-current coordination curves
    - b. Power system data
  2. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
  3. Operation and Maintenance Procedures: In addition, provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

#### 1.7 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this section. Manual calculations are unacceptable.

- B. Study Software Developer 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. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Power Study Specialist Qualifications: Professional engineer in charge of performing the study 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.
- D. Field Adjusting Agency Qualifications: Licensed electrician.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Comply with IEEE 242, IEEE 399, IEEE 1584 and NFPA 70E.
- B. Analytical features of the power study computer software program shall have the 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. 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 REPORT CONTENTS

- A. Executive summary
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings
  - 2. Cable size and lengths
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings
  - 4. Motor and generator designations and kVA ratings
  - 5. Panelboard designations

- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output:
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.
  4. Protective Device Evaluation:
    - a. Evaluate equipment and protective devices and compare to short-circuit ratings.
    - b. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
    - c. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
    - d. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
    - e. 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. 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. Circuit Breakers:
    - 1) Adjustable pickups and time delays (long time, short time, ground)
    - 2) Adjustable time-current characteristic
    - 3) Adjustable instantaneous pickup
    - 4) Recommendations on improved trip systems, if applicable
  - b. Fuses: Show current rating, voltage, and class.
- G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination where code required. Graphically illustrate that adequate time separation exists between devices installed in series, including power campus 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 recommended instantaneous settings.
  4. Plot the following listed characteristic curves, as applicable:
    - a. Campus overcurrent protective device
    - b. Medium-voltage equipment overcurrent relays
    - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
    - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands
    - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
    - f. Cables and conductors damage curves
    - g. Ground-fault protective devices
    - h. Motor-starting characteristics and motor damage points
    - i. Generator short-circuit decrement curve and generator damage point
    - j. The largest feeder circuit breaker in each motor-control center and panelboard
  5. Provide adequate time margins between device characteristics such that selective operation is achieved where required.
  6. Comments and recommendations for system improvements.
- H. Arc Flash Study Output
  1. Incident Energy and Flash Protection Boundary Calculations:
    - a. Arcing fault magnitude.
    - b. Protective device clearing time.
    - c. Duration of arc.
    - d. Arc-flash boundary.

- e. Working distance.
  - f. Incident energy.
  - g. Recommendations for arc-flash energy reduction.
- I. Study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.
- J. Arc Flash Warning Labels
  - 1. Produce a size as appropriate with a minimum size of 3"x4" self-adhesive equipment label for each work location included in the analysis.
  - 2. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
    - a. Location designation.
    - b. Nominal voltage.
    - c. Flash protection boundary.
    - d. Incident energy.
    - e. Working distance.
    - f. Engineering report number, revision number, and issue date.
    - g. Shock risk.
    - h. Glove Class.
    - i. Available short circuit
  - 3. Labels shall be machine printed, with no field-applied markings.
  - 4. 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.
  - 5. 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.
  - 6. 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 EXAMINATION

- A. Proceed with coordination and arc flash 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 the studies.

### 3.2 STUDY ANALYSIS

- 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. Calculate short-circuit currents according to IEEE 551.
- D. Comply with NFPA 70E and its annex D for hazard analysis study.
- E. The study shall be based on the device characteristics supplied by device manufacturer.
- F. Contributions from motors is for those rated 50 horsepower or greater.
- G. The extent of the electrical power system to be studied is indicated on Drawings.
- H. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
  - 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 30 kVA.
- I. 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.
- J. 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.

- K. 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.
- L. 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.
- M. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.
- N. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
  - 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.
- O. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
  - 1. Campus supply termination point.
  - 2. Switchgear.
  - 3. Unit substation primary and secondary terminals.
  - 4. Low-voltage switchgear.
  - 5. Motor-control centers.
  - 6. Standby generators and automatic transfer switches.
  - 7. Branch circuit panelboards.
  - 8. Control panel.
  - 9. Disconnect switch.
- P. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  - 2. Adequacy of panelboard bus bars to withstand short-circuit stresses.
  - 3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.
- Q. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- R. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- S. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
  2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- T. Arc-flash computation shall include the higher value of 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 not separate from the work location.
- U. 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 the conduct of the overcurrent protective device study.
1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Engineer.
  2. For new equipment, use characteristics submitted under the 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. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support power study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field.
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. Campus impedance at the service.
  3. Power sources and ties.
  4. Short-circuit current at each system bus, three phase and line-to-ground.
  5. Voltage level at each bus.
  6. For transformers, include kVA, primary and secondary voltages, connection type, impedance and X/R ratio.
  7. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
  8. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
  9. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  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, and conductor material.
  12. Motor horsepower and NEMA MG 1 code letter designation.

13. Low-voltage cable sizes, lengths, number, conductor material.
14. Reference to project submittals including data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Generator thermal-damage curve.
  - e. Ratings, types, and settings of utility company's overcurrent protective devices.
  - f. Special overcurrent protective device settings or types stipulated by utility company.
  - g. Time-current-characteristic curves of devices indicated to be coordinated.
  - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
  - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment.

### 3.4 FIELD ADJUSTING

- A. Adjust protective device settings according to the recommended settings provided by the coordination study.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

### 3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel in the following:
  1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
  2. Hand-out and explain the objectives of the power system study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
  3. Adjust, operate, and maintain overcurrent protective device settings.
  4. The potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

### 3.6 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Control panel.
2. Transformer.
3. Disconnect switches.

### 3.7 APPLICATION OF WARNING LABELS

- A. Clean area of equipment prior to label application.
- B. Install the arc-fault warning labels square on equipment
- C. Label shall not cover any manufacturer provided information.

END OF SECTION

## SECTION 26 09 23 - LIGHTING CONTROL DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Photoelectric switches.
  - 2. Standalone daylight-harvesting switching and dimming controls.
  - 3. Indoor occupancy and vacancy sensors.
- B. Related Requirements:
  - 1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Show installation details for the following:
    - a. Occupancy sensors.
    - b. Vacancy sensors.
    - c. Daylight Harvesting Controls
  - 2. Interconnection diagrams showing field-installed wiring.
  - 3. Include diagrams for power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Contractor shall provide reflected ceiling plan(s) and elevations, 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. Structural members to which equipment will be attached.
  - 3. Items penetrating finished ceiling, including the following:
    - a. Luminaires.

- b. Air outlets and inlets.
- c. Speakers.
- d. Sprinklers.
- e. Access panels.
- f. Occupancy Sensors
- g. Vacancy Sensors.
- h. Daylight Harvesting Sensors.

- B. Field quality-control reports.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On USB media On manufacturer's website. Provide names, versions, and website addresses for locations of installed software.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.

## 1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Faulty operation of lighting control software.
    - b. Faulty operation of lighting control devices.
  - 2. Warranty Period: Two year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Industries, Inc.
  - 2. Intermatic, Inc.
  - 3. Leviton Manufacturing Co., Inc.
  - 4. Watt Stopper; a Legrand at Group Brand.
- B. Description: Solid state, with SPST DPST dry contacts rated for 1800 VA inductive, to operate connected load, complying with UL 773, and compatible with LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
  3. Time Delay: Thirty-second minimum, to prevent false operation.
  4. Lightning Arrester: Air-gap type.
  5. Mounting: Twist lock complying with NEMA C136.10, with base.
  6. Failure Mode: Luminaire stays ON.
- C. Description: Solid state; one set of NO dry contacts rated for 24 V dc at 1 A, to operate connected load, complying with UL 773, and compatible with luminaire power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
  3. Time Delay: Thirty-second minimum, to prevent false operation.
  4. Mounting: 1/2-inch threaded male conduit.
  5. Failure Mode: Luminaire stays ON.
  6. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
- a. LED status lights to indicate load status.
  - b. Plenum rated.

## 2.2 DAYLIGHT-HARVESTING SWITCHING CONTROLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
  2. Eaton.
  3. Hubbell Building Automation, Inc.
  4. Leviton Manufacturing Co., Inc.
  5. Watt Stopper; a Legrand® Group brand.
- B. Description: System operates indoor lighting.
- C. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.
1. Lighting control set point is based on two lighting conditions:
    - a. When no daylight is present.
    - b. When significant daylight is present (target level).
    - c. System programming is done with two hand-held, remote-control tools.
- D. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with integrated power pack, that detects changes in indoor lighting levels that are perceived by the eye.
- E. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Sensor Output: Contacts rated to operate the associated power pack, complying with UL 773A. Sensor shall be powered by the power pack.
4. Sensor Output: Digital signal compatible with power pack.
5. Sensor type: Open loop.
6. Zone: Single.
7. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
  - a. LED status lights to indicate load status.
  - b. Plenum rated.
8. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
9. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
10. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
11. Test Mode: User selectable, overriding programmed time delay to allow settings check.
12. Control Load Status: User selectable to confirm that load wiring is correct.
13. Indicator: Two digital displays to indicate the beginning of on-off cycles.

## 2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
  1. Lighting control set point is based on two lighting conditions:
    - a. When no daylight is present (target level).
    - b. When significant daylight is present.
  2. System programming is done with two hand-held, remote-control tools.
    - a. Initial setup tool.
    - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
- B. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated power pack, to detect changes in indoor lighting levels that are perceived by the eye.
- C. Electrical Components, Devices, and Accessories:
  1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
  3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

- D. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

1. LED status lights to indicate load status.
2. Plenum rated.

## 2.4 INDOOR OCCUPANCY AND VACANCY SENSORS

### A. General Requirements for Sensors:

1. Wall Ceiling-mounted, solid-state indoor occupancy sensors.
2. Passive infrared Ultrasonic Dual technology.
3. Integrated power pack.
4. Hardwired connection to switch.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:
  - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:
  - a. Sensor: Suitable for mounting in any position on a standard outlet box.
  - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
  - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

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

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet 2000 square feet 3000 square feet when mounted 48 inches above finished floor.

## 2.5 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 SENSOR INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

### 3.3 CONTACTOR INSTALLATION

- A. Comply with NECA 1.

- B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

### 3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified NETA or NICET testing agency to evaluate lighting control devices and 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:
  - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

### 3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
  - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
  - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
  - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

### 3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
  - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

### 3.9 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260923 – “Lighting Control Devices” and Section 260936 – “Modular Dimming Controls:”
- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 26 09 23

## SECTION 26 09 36 - MODULAR DIMMING CONTROLS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Wall-box, multiscene, modular dimming controls.
  - 2. Multipreset modular dimming controls.

#### 1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
- C. Low Voltage: As defined in NFPA 70, the term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.
- D. RFI: Radio-frequency interference.
- E. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
- F. SCR: Silicon-controlled rectifier.
- G. Zone: A luminaire or group of luminaires controlled simultaneously as a single entity. Also known as a "channel."

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
  - 2. Device plates and plate color and material.
  - 3. Ballast and lamp combinations compatible with dimmers.
  - 4. Sound data including results of operational tests of central dimming controls.
  - 5. Operational documentation for software and firmware.

- B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
  - 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. Address Drawing: Contractor shall provide a detailed reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
  - 4. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
  - 5. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems.
  - 1. Show interconnecting signal and control wiring, and interface devices that show compatibility of inputs and outputs.
  - 2. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For standalone multipreset modular dimming controls to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 018300 "Operation and Maintenance Data," include the following:
    - a. Software manuals.
    - b. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
    - c. Operation of adjustable zone controls.
    - d. Testing and adjusting of panic and emergency power features.

#### 1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular dimming controls 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.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Leviton Manufacturing Co., Inc.
  2. Lightolier; a Philips group brand.
  3. Lutron Electronics Co., Inc.
  4. Philips Lighting Controls.

### 2.2 SYSTEM DESCRIPTION

- A. Compatibility:
1. Dimming control components shall be compatible with luminaires.
  2. Dimming control devices shall be compatible with lighting control system components specified in Section 260936 "Modular Dimming Controls" and in Section 260923 "Lighting Control Devices."
- B. Dimmers and Dimmer Modules: Comply with UL 508.
1. Audible Noise and RFI Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules shall include integral or external filters to suppress audible noise and RFI.
  2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.
- C. Capacities: Unit shall be rated for 2400 W at 240-V ac and 2000 W at 120-V ac for up to 100 devices or zones.
- D. Surge Protection: Withstand supply power surges without impairment to performance.
1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
  2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
- E. Off Control Position: User-selected off position of any control point shall disconnect the load from line supply.

- 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 CONDUCTORS AND CABLES

- A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Label each dimmer module with a unique designation.
- C. Label each scene control button with approved scene description.

### 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:
  - 1. Continuity tests of circuits.
  - 2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

- a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
- C. Dimming control components will be considered defective if they do not pass tests and inspections.
- D. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- E. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

#### 3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls.
- B. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Section 260923 "Lighting Control Devices".

END OF SECTION 26 09 36

## SECTION 26 24 16 - 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. Product Data: For each type of panelboard.
  - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
  - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details.
  - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
  - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.

4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log 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. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 08300 "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.
  5. .

#### 1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407.

#### 1.10 FIELD CONDITIONS

- A. Environmental Limitations:
  - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
  - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
    - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
  - 1. Ambient temperatures within limits specified.
  - 2. Altitude not exceeding 6600 feet.

#### 1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
  - 1. Panelboard Warranty Period: 24 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. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. 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.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: 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 or Type 4X.
    - c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250 Type 1.
  - 2. Height: 84 inches maximum.
  - 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
  - 4. Finishes:
    - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    - b. Back Boxes: Galvanized steel.
- G. Incoming Mains:
  - 1. Location: Top Bottom Convertible between top and bottom.
  - 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- H. 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.
- I. 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: Compression type, with a lug on the neutral bar for each pole in the panelboard.
  - 5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.

6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
  7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
  8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
  9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
- K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: Five percent.
  2. Provide Door-In-Door construction for all panel board doors with full length "piano" style hinges .
- L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
1. Panelboards 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 rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

## 2.3 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
  2. General Electric Company; GE Energy Management - Electrical Distribution.
  3. SIEMENS Industry, Inc.; Energy Management Division.
  4. Square D; by Schneider Electric.

- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
  - 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker Lugs only.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.
- G. Branch Overcurrent Protective Devices: Fused switches.

## 2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton.
  - 2. General Electric Company; GE Energy Management - Electrical Distribution.
  - 3. SIEMENS Industry, Inc.; Energy Management Division.
  - 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

## 2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. MCCB: Comply with UL 489, with series-connected rating to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers:
    - a. Inverse time-current element for low-level overloads.
    - b. Instantaneous magnetic trip element for short circuits.
    - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers (300A and larger): Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
  - a. RMS sensing.
  - b. Field-replaceable rating plug or electronic trip.
  - c. Digital display of settings, trip targets, and indicated metering displays.
  - d. Multi-button keypad to access programmable functions and monitored data.
  - e. Ten-event, trip-history log. Each trip event 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.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
7. Subfeed Circuit Breakers: Vertically mounted.
8. MCCB Features and Accessories:
  - a. Standard frame sizes, trip ratings, and number of poles.
  - b. Breaker handle indicates tripped status.
  - c. UL listed for reverse connection without restrictive line or load ratings.
  - d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
  - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
  - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - g. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
  - h. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at **[55] [75]** percent of rated voltage.
  - i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
  - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off 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 a steel frame with a 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.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NECA 407 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.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches 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.
  - 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.
- I. 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.
- J. Install filler plates in unused spaces.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

### 3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

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 and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
  - a. Initial Infrared Scanning: At on-site functional performance testing, 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 indicated.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
1. Measure loads during period of normal facility operations.
  2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
  4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

## SECTION 26 27 26 - WIRING DEVICES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Standard-grade receptacles, 125 V, 20 A.
  - 2. USB receptacles.
  - 3. GFCI receptacles, 125 V, 20 A.
  - 4. Twist-locking receptacles.
  - 5. Occupancy sensors.
  - 6. Wall-box dimmers.
  - 7. Wall plates.
  - 8. Floor service fittings.
  - 9. Poke-through assemblies.
  - 10. Prefabricated multioutlet assemblies.

#### 1.3 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

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 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 plugs configurations.
  - 2. Cord and Plug Sets: Match equipment requirements.
- F. Device Color:
  - 1. Wiring Devices Connected to Normal Power System: Black unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices Connected to UPS Electrical System: Blue
  - 3.
- G. Wall Plate Color: Stainless steel except red receptacles to have red wall plates.
- H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

- A. Duplex Receptacles, 125 V, 20 A:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.

- c. Leviton Manufacturing Co., Inc.
    - d. Pass & Seymour/Legrand (Pass & Seymour).
  - 2. Description: Two pole, three wire, and self-grounding.
  - 3. Configuration: NEMA WD 6, Configuration 5-20R.
  - 4. Standards: Comply with UL 498 and FS W-C-596.
  - 5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
- B. Weather-Resistant Duplex Receptacle, 125 V, 20 A:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
    - d. Pass & Seymour/Legrand (Pass & Seymour).
  - 2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
  - 3. Configuration: NEMA WD 6, Configuration 5-20R.
  - 4. Standards: Comply with UL 498.
  - 5. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.
- 2.3 GFCI RECEPTACLES, 125 V, 20 A
- A. Duplex GFCI Receptacles, 125 V, 20 A:
- 1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
  - 2. Configuration: NEMA WD 6, Configuration 5-20R.
  - 3. Type: Feed through.
  - 4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
- 2.4 TWIST-LOCKING RECEPTACLES
- A. Twist-Lock, Single Receptacles, 120 V, 20 A:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
    - d. Pass & Seymour/Legrand (Pass & Seymour).
  - 2. Configuration: NEMA WD 6, Configuration L5-20R.

3. Standards: Comply with UL 498.

## 2.5 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.

## 2.6 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
  1. Plate-Securing Screws: Metal with head color to match plate finish.
  2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting Smooth, high-impact thermoplastic 0.035-inch-thick, satin-finished, Type 302 stainless steel 0.04-inch-thick, brushed brass with factory polymer finish 0.05-inch-thick, anodized aluminum 0.04-inch-thick steel with chrome-plated finish.
  3. Material for Unfinished Spaces: Galvanized steel Smooth, high-impact thermoplastic.
  4. Material for Damp Locations: Thermoplastic or Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum or thermoplastic with lockable cover.
- D. Antimicrobial Cover Plates:
  1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
  2. Tarnish resistant.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
  1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
  - a. Cut back and pigtail, or replace all damaged conductors.
  - b. Straighten conductors that remain and remove corrosion and foreign matter.
  - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### 3.2 GFCI RECEPTACLES

- A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

### 3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

### 3.4 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Perform the following tests and inspections:
  - 1. Test Instruments: Use instruments that comply with UL 1436.
  - 2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Receptacles:
  - 1. Line Voltage: Acceptable range is 105 to 132 V.
  - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 26 27 26

## SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Shunt trip switches.
  - 4. Molded-case circuit breakers (MCCBs).
  - 5. Molded-case switches.
  - 6. Enclosures.

#### 1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
  - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.
- B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 018300 "Operation and Maintenance Data," include the following:
    - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
    - b. Time-current coordination curves (average melt) for each type and rating of over-current protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  2. Fuse Pullers: Two for each size and type.

#### 1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
  1. Testing Agency's Field Supervisor: Currently certified by NETA or NICET to supervise on-site testing.

## 1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  - 2. Altitude: Not exceeding 6600 feet.

## 1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Two (2)year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

### 2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

### 2.3 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
  - 1. Single throw.
  - 2. Three pole.
  - 3. 240-V ac and 600-V ac.

4. 200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac 208-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

## 2.4 NONFUSIBLE SWITCHES

- A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600-V ac and 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 240-V ac, 600-V ac and 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Three Pole, Double Throw, 240-V ac, 600-V ac and 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
  1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
  4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac 208-V ac.
  6. Hookstick Handle: Allows use of a hookstick to operate the handle.
  7. Lugs: Mechanical type, suitable for number, size, and conductor material.
  8. Service-Rated Switches: Labeled for use as service equipment.

## 2.5 SHUNT TRIP SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Busmann, an Eaton business.
  - 2. Littelfuse, Inc.
  - 3. Mersen USA.
- B. General Requirements: Comply with UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.
- C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 240-V ac, 600-V ac and A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 240-Vac and 600-V ac, A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- E. Control Circuit: 120-V ac; obtained from an integral fusible (3 fuses) control power source of enough capacity to operate shunt trip, pilot, indicating and control devices.
- F. Accessories:
  - 1. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
  - 2. Form C alarm contacts that change state when switch is tripped.
  - 3. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac 208-V ac.
  - 4. Hookstick Handle: Allows use of a hookstick to operate the handle.
  - 5. Lugs: Mechanical type, suitable for number, size, and conductor material.
  - 6. Service-Rated Switches: Labeled for use as service equipment.

## 2.6 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton.
  - 2. General Electric Company.
  - 3. SIEMENS Industry, Inc.; Energy Management Division.
  - 4. Square D; by Schneider Electric.
- B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indi-

cation. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

- D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated or series rated as indicated on the Drawings. combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. \_\_\_\_\_ Amps Available. Identical Replacement Component Required."
- E. MCCBs shall be equipped with a device for locking in the isolated position.
- F. Lugs shall be suitable for 194 deg F rated wire, sized according to the 167 deg F temperature rating in NFPA 70.
- G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- J. Electronic Trip Circuit Breakers (400A and Larger): Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
  - 1. Instantaneous trip.
  - 2. Long- and short-time pickup levels.
  - 3. Long- and short-time time adjustments.
  - 4. Ground-fault pickup level, time delay, and I-squared t response.
- K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- O. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.
  - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
  - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, fusible (3-fuses) 208-V ac or 480-V ac.

## 2.7 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Eaton.
  2. General Electric Company.
  3. SIEMENS Industry, Inc.; Energy Management Division.
  4. Square D; by Schneider Electric.
- B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- D. Features and Accessories:
  1. Standard frame sizes and number of poles.
  2. Lugs:
    - a. Mechanical type, suitable for number, size, trip ratings, and conductor material.
    - b. Lugs shall be suitable for 194 deg F rated wire, sized according to the 167 deg F temperature rating in NFPA 70.
  3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
  5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
  6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.

7. Alarm Switch: One NO contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, fusible (3-fuses) 208-V ac or 480-V ac.

## 2.8 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1) directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- D. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- E. NEMA 250 Type 7 and 9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
  1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

### 3.2 PREPARATION

### 3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
  - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - 2. Outdoor Locations: NEMA 250, Type 3R Type 4X.
  - 3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
  - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

### 3.4 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

### 3.5 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections for Switches:
  - 1. Visual and Mechanical Inspection:
    - a. Inspect physical and mechanical condition.
    - b. Inspect anchorage, alignment, grounding, and clearances.
    - c. Verify that the unit is clean.
    - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
    - e. Verify that fuse sizes and types match the Specifications and Drawings.

- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the two following methods:
  - 1) Use a low-resistance ohmmeter.
    - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
    - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify that the unit is clean.
- e. Operate the circuit breaker to ensure smooth operation.

- f. Inspect bolted electrical connections for high resistance using one of the two following methods:
  - 1) Use a low-resistance ohmmeter.
    - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
    - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- g. Inspect operating mechanism, contacts, and chutes in unsealed units.
- h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
- e. Determine the following by primary current injection:
  - 1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

- f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
    - g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
    - h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
    - i. Verify operation of charging mechanism. Investigate units that do not function as designed.
  - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 4. Perform the following infrared scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
  - D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
  - E. Prepare test and inspection reports.
    - 1. Test procedures used.
    - 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
    - 3. List deficiencies detected, remedial action taken, and observations after remedial action.
- 3.7 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 to values indicated on the Drawings.

END OF SECTION 26 28 16

## SECTION 26 32 13.13 - DIESEL EMERGENCY ENGINE GENERATORS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes packaged diesel engine generators for emergency use with the following features:
  - 1. Diesel engine.
  - 2. Diesel fuel-oil system.
  - 3. Control and monitoring.
  - 4. Generator overcurrent and fault protection.
  - 5. Generator, exciter, and voltage regulator.
  - 6. Outdoor engine generator enclosure.
  - 7. Finishes.
- B. Related Requirements:
  - 1. Section 263600 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

#### 1.3 DEFINITIONS

- A. EPS: Emergency power supply.
- B. EPSS: Emergency power supply system.
- C. Operational Bandwidth: The total variation, from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Include thermal damage curve for generator.
  - 3. Include time-current characteristic curves for generator protective device.
  - 4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.

5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer manufacturer and testing agency.
- B. Source Quality-Control Reports: Including, but not limited to, the following:
1. Certified summary of prototype-unit test report.
  2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
  3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
  4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
  5. Report of sound generation.
  6. Report of exhaust emissions showing compliance with applicable regulations.
  7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 018300 "Operation and Maintenance Data," include the following:

- a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- b. Operating instructions laminated and mounted adjacent to generator location.
- c. Training plan.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
  2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
  4. Tools: Each tool listed by part number in operations and maintenance manual.

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained, certified and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA or NICET.
  1. Testing Agency's Field Supervisor: Certified by NETA NICET and generator manufacturer to supervise on-site testing.

#### 1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  1. The generator set shall include a standard warranty covering five (5) years or 3000 hours whichever occurs first, to guarantee against defective material and workmanship in accordance with the manufacturer published warranty from the date of initial startup.
  2. The generator set manufacturer and its distributor shall maintain a 24-hour parts and service organization. This organization shall regularly engage in maintenance contract programs to perform preventive maintenance and service on equipment similar to that specified. A service agreement shall be available and shall include system operation under simulated operating conditions; adjustment to generator set, transfer switch, and switch-gear controls as required, and certification in the owner's maintenance log of repairs made and functional test performed on all systems. .

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Kohler Generation.
  - 2. Caterpillar Power Systems Inc.
  - 3. MTU Onsite Energy Corporation.
- B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

- A. B11 Compliance: Comply with B11.19.
- B. NFPA Compliance:
  - 1. Comply with NFPA 37.
  - 2. Comply with NFPA 70.
  - 3. Comply with NFPA 99.
  - 4. Comply with NFPA 110 requirements for Level 1 EPSS.
- C. UL Compliance: Comply with UL 2200.
- D. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.
- E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: 41 to 104 deg F.
  - 2. Relative Humidity: Zero to 95 percent.
  - 3. Altitude: Sea level to 1000 feet.

## 2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. EPSS Class: Engine generator shall be classified as a Class 2 according to NFPA 110.
- D. Service Load: As indicated on drawing.
- E. Power Factor: 0.8, lagging.

- F. Frequency: 60 Hz
- G. Voltage: As indicated on drawings.
- H. Phase: Three-phase, four-wire wye.
- I. Induction Method: Naturally aspirated.
- J. Governor: Adjustable isochronous, with speed sensing.
- K. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- L. Capacities and Characteristics:
  - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
  - 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.
- M. Engine Generator Performance:
  - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
  - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within five seconds.
  - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
  - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 5. Transient Frequency Performance: Less than 10 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within six seconds.
  - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - 7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  - 8. Start Time: Comply with NFPA 110, Type 10 system requirements.
- N. Engine Generator Performance for Sensitive Loads:
  - 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

- a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage, from no load to full load.
3. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency, from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operating band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content, measured line to neutral, shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by non-linear load.
  - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

## 2.4 DIESEL ENGINE

- A. Fuel: ASTM D 975 off road diesel fuel oil, Grade 2-D S15.
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: Engine or skid mounted.
  1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Jacket Coolant Heater: Electric-immersion type, sized for 480V operation factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499. If heater is factory standard 240V. heater shall be increased in KW to compensate for 208V. operation.

- E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
  3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and pet-cock.
  4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
  5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
    - a. Rating: 50-psig 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.
- F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. Silencer shall be installed completely within the weatherproof housing. Exhaust piping shall be provided with a spring loaded rain cap.
1. Minimum sound attenuation of 18 dB at 500 Hz.
  2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 72 dBA or less.
  3. Muffler shall be provided with an insulation jacket covered with a 360° aluminum jacket cover.
- G. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- H. Starting System: 24 V electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
  2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  3. Cranking Cycle: As required by NFPA 110 for system level specified.
  4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least 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. Provide a thermostatically controlled heater that shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.

7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
  - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
  - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent over-charging at high temperatures and undercharging at low temperatures.
  - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
  - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
  - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
  - f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

## 2.5 DIESEL FUEL-OIL SYSTEM

- A. Comply with NFPA 30.
- B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.
- C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.
- D. Fuel Filtering: Remove water and contaminants larger than 1 micron.
- E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess / un-used fuel to fuel oil storage tank.
- F. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:
  1. Tank level indicator.
  2. Fuel-Tank Capacity: 72 hours of fuel capacity at 100% of rated output of engine, total fuel required for periodic maintenance operations between fuel refills, plus fuel for the hours of continuous operation for indicated EPSS class.
  3. Leak detection in interstitial space.
  4. Vandal-resistant fill cap.
  5. Containment Provisions: Comply with requirements of authorities having jurisdiction.
  6. Exterior Finish: The sub-base tank exterior finish shall be Power Armor Plus TM, a poly-urea-textured rubberized coating.

- G. Provide fuel for generator load bank testing. Provide replacement fuel for 100% fuel oil storage capacity.

## 2.6 CONTROL AND MONITORING

- A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Manual-Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- C. Provide minimum run time control factory set for 30 minutes, with override only by operation of a remote emergency-stop switch.
- D. Comply with UL 508A.
- E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
- F. Control and Monitoring Panel:
  - 1. Advanced Power Management 603 (APM603) Generator Set Controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
  - 2. Instruments: Located on the control and monitoring panel and viewable during operation.
    - a. Communication Connections
      - 1) Modbus, CAN, SNMP and BACNet communications shall be accessible in a dedicated customer connection area that is separated from factory wiring into the controller to prevent field connections from interfering with factory wiring.
      - 2) The controller shall not require any additional hardware to support Modbus, SNMP or BACnet communication.
    - b. Engine lubricating-oil pressure gage.
    - c. Engine-coolant temperature gage.
    - d. DC voltmeter (alternator battery charging).
    - e. Running-time meter.
    - f. AC voltmeter, for each phase.
    - g. AC ammeter, for each phase.
    - h. AC frequency meter.
    - i. Generator-voltage-adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level [1] [2] system, including the following:

- a. Cranking control equipment.
- b. Run-Off-Auto switch.
- c. Control switch not in automatic position alarm.
- d. Overcrank alarm.
- e. Overcrank shutdown device.
- f. Low water temperature alarm.
- g. High engine temperature.
- h. High engine temperature shutdown device.
- i. Overspeed alarm.
- j. Overspeed shutdown device.
- k. Low-fuel main tank.

- 1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

- l. Coolant low-level alarm.
- m. EPS load indicator.
- n. Battery high-voltage alarm.
- o. Low-cranking voltage alarm.
- p. Battery-charger malfunction alarm.
- q. Battery low-voltage alarm.
- r. Lamp test.
- s. Contacts for local and remote common alarm.
- t. Low-starting air pressure alarm.
- u. Remote manual-stop shutdown device.
- v. Air shutdown damper alarm when used.
- w. Air shutdown damper shutdown device when used.
- x. Generator overcurrent-protective-device not-closed alarm.

- G. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and flush-mounting type to suit mounting conditions indicated.

- 1. Overcrank alarm.
- 2. Coolant low-temperature alarm.
- 3. High engine temperature prealarm.
- 4. High engine temperature alarm.
- 5. Low lube oil pressure alarm.
- 6. Overspeed alarm.
- 7. Low-fuel main tank alarm.
- 8. Low coolant level alarm.
- 9. Low-cranking voltage alarm.
- 10. Contacts for local and remote common alarm.
- 11. Audible-alarm silencing switch.
- 12. Air shutdown damper when used.
- 13. Run-Off-Auto switch.
- 14. Control switch not in automatic position alarm.
- 15. Fuel tank derangement alarm.

16. Fuel tank high-level shutdown of fuel-supply alarm.
  17. Lamp test.
  18. Low-cranking voltage alarm.
  19. Generator overcurrent protective device not closed.
- H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.
- I. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation. Mount next to remote alarm annunciator
- J. Install remote alarm annunciator in emergency operations center, room 110e. Coordinate exact location with facilities manager.

## 2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
  2. Trip Settings: Selected to coordinate with generator thermal damage curve.
  3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
  4. Mounting: Adjacent to or integrated with control and monitoring panel.
  5. Provide a second output breaker of same type for connection of a portable load bank for testing.
- C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
  2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
  3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
  4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

- D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
  - 1. Indicate ground fault with other engine generator alarm indications.
  - 2. Trip generator protective device on ground fault.

## 2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H, 150°C temperature rise.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six-lead alternator.
- E. Range: Provide limited range of output voltage by adjusting the excitation level.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Drip-proof.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
  - 1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
  - 2. Maintain voltage within 15 percent on one step, full load.
  - 3. Provide anti-hunt provision to stabilize voltage.
  - 4. Maintain frequency within 5 percent and stabilize at rated frequency within two seconds.
- I. Strip Heater: Provide a thermostatically controlled heater arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

## 2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

- A. Level 2 Sound Attenuated Enclosure
  - 1. The generator set shall be supplied with a hurricane rated (200mph) Level 2 Sound Attenuated Enclosure that is UL2200 listed, providing a sound pressure of 72 dB(A) while the generator is operating at 100% load at 7 meters (23 feet) using acoustic insulation and acoustic-lined inlet hoods, and using acoustic insulation and acoustic-lined inlet hoods, constructed from a minimum of 0.125 inch thick formed heavy duty aluminum panels. The acoustic insulation used shall meet UL 94 HF1 flammability classification. The enclosure shall be manufactured from bolted panels to facilitate service, future modi-

fications, or field replacement. The enclosure shall use a vertically louvered air inlet and outlet hood with 90-degree angle to discharge air up and reduce noise. The enclosure shall have an integral rodent guard and skid end caps. The enclosure shall be certified to 186 mph (299 kph) wind load rating. The snow load rating shall be 70 lbs./ sq. ft. or greater.

2. The enclosure components and skid shall be cleaned with a two-stage alkaline cleaning process to remove grease, grit, and grime from parts. Components shall then be subjected to a Zirconium-based conversion coating process to prepare the metal for electro-coat (e-coat) adhesion. All enclosure parts shall receive a 100% epoxy primer electro-coat (e-coat) with high-edge protection. Following the e-coat process, the parts shall be finish coated with powder baked paint for superior finish, durability, and appearance with a Power Armor TM industrial finish that provides heavy duty durability in harsh conditions, and is fade-, scratch- and corrosion-resistant.
3. The enclosure must surpass a 3,000 hour salt spray corrosion test per ASTM B-1117.
4. Enclosures will be finished in the manufacturer's standard color.
5. The enclosures shall allow the generator set to operate at full load based on the cooling capability of the genset. The enclosure will account for no more than a 5°C derating of the ambient cooling capability of the generator.
6. Enclosures shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker shall meet the requirements of the National Electric Code.
7. The enclosure shall be furnished with stainless steel latches, hinges and hardware on the external panels of the enclosure. Access doors shall be rubber sealed to prevent water intrusion and to minimize noise.
8. Doors shall be equipped with lockable latches. Locks shall be keyed alike. Door locks shall be recessed to minimize potential of damage to door/enclosure.
9. A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.
10. Housing to have lights, heater, gfi receptacle and a panelboard rated 120/208V 4W. Factory connect all ancillary equipment including battery charger and jacket water heater to panel with wiring installed in rigid steel conduit and liquid tight metal conduit connections to vibrating equipment.
11. The complete exhaust system shall be internal to the enclosure. 1.11 The critical silencer shall be fitted with a tailpipe and rain cap. 1.12 Hurricane rated sound aluminum enclosure
  - a. Must conform to Florida Building Code.
  - b. Enclosures are tested and certified per standards
    - 1) Large Missile Impact Level E (FBC TAS 201-94)
    - 2) Uniform Static Air Pressure (FBC TAS-202-94)
    - 3) Cyclic Wind Pressure Loading (FBC TAS 203-94)
    - 4) Ultimate Design Pressure – Wall Panels ±65PSF
    - 5) Ultimate Design Pressure – Roof Panels ±100PSF.
  - c. Enclosures must be tested and certified by a certified third party.

## 2.10 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of suffi-

cient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene separated by steel shims.
2. Minimum Deflection: 1 inch.

- B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

## 2.11 FINISHES

- A. Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.12 SOURCE QUALITY CONTROL

- A. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  2. Test generator, exciter, and voltage regulator as a unit.
  3. Step load test: 30% load, 50% load, 75% load and 100% load test. Test each load for 15 minutes. When step load testing is complete provide two 100% block load tests.
  4. Maximum power.
  5. Voltage regulation.
  6. Transient and steady-state governing.
  7. Single-step load pickup.
  8. Safety shutdown.
  9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
  10. Report factory test results within 10 days of completion of test.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 404.

- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.
- C. Equipment Mounting:
  - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Concrete base shall be 12" larger than the generator set in all directions.
  - 2. Coordinate size and location of concrete bases for packaged engine generators on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.
- C. Connect engine exhaust pipe to engine with flexible connector.
- D. 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." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.
- F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

### 3.4 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor shall engage a qualified NETA or NICET certified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Contractor shall provide the services of Engage a factory-trained service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform all tests and inspections with the assistance of a factory-trained service representative.
- D. Tests and Inspections:
  - 1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.
    - a. Visual and Mechanical Inspection:
      - 1) Compare equipment nameplate data with Drawings and the Specifications.
      - 2) Inspect physical and mechanical condition.
      - 3) Inspect anchorage, alignment, and grounding.
      - 4) Verify that the unit is clean.
    - b. Electrical and Mechanical Tests:
      - 1) Perform insulation-resistance tests according to IEEE 43.
        - a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
        - b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
      - 2) Test protective relay devices.
      - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
      - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
      - 5) Perform vibration test for each main bearing cap.
      - 6) Conduct performance test according to NFPA 110.
      - 7) Verify correct functioning of the governor and regulator.
  - 2. NFPA 110 Acceptance Tests: Perform on-site functional performance testing at 30%, 50%, 75% and 100% loads for 30 minutes each, and two block load 100% block load tests. Provide a resistive type load bank and all required cabling for testing purposes. Tests required by NFPA 110 that are additional to those specified here, including, but not limited to, two single-step full-load pickup test.
  - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

- c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
  - 7. Exhaust Emissions Test: Comply with applicable government test criteria.
  - 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - 9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  - 10. Noise-Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet from edge of the generator enclosure on the property line, or edge of building line; whichever is closer and compare measured levels with required values.
- E. Coordinate tests with tests for transfer switch testing , and test them concurrently.
- F. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and retest as specified above.
- K. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.
- M. Infrared Scanning: At on-site functional performance acceptance testing, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan at 6 month and 12 months during regular routing maintenance testing.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at performance acceptance testing, maintenance service shall include test at 3 months, 6 months, 9 months and at the 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include semi-annual preventive maintenance and exercising to check for proper starting, load transfer, and running under load for a period of four (4) years. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

### 3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13.13

## SECTION 26 33 53 - STATIC UNINTERRUPTIBLE POWER SUPPLY

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
    - a. Surge suppression.
    - b. Rectifier-charger.
    - c. Inverter.
    - d. Controls and indications.
    - e. Static bypass transfer switch.
    - f. Internal maintenance bypass/isolation switch.
    - g. Output distribution section.
    - h. Output isolation transformers.
    - i. Remote status and alarm panels.
    - j. Remote monitoring provisions.
    - k. Battery and battery disconnect device.
    - l. Battery monitoring.

#### 1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GTO: Gate turn-off thyristor.
- C. IGBT: Isolated gate bipolar transistor.
- D. LCD: Liquid-crystal display.
- E. LED: Light-emitting diode.
- F. NiCd: Nickel cadmium.
- G. PC: Personal computer.
- H. SPD: Surge protection device.
- I. THD: Total harmonic distortion.

- J. UPS: Uninterruptible power supply.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each UPS.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include wiring diagrams for power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Product Certificates: For each product, from manufacturer.
- C. Factory Test Reports: Comply with specified requirements.
- D. Product Test Reports: Indicate test results compared with specified performance requirements and provide justification and resolution of differences if values do not agree.
- E. Field quality-control reports.
- F. Sample Warranties: For manufacturer's special warranties.

#### 1.6 CLOSEOUT SUBMITTALS

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

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
  2. Cabinet Ventilation Filters: One complete set(s).

1.8 QUALITY ASSURANCE

- A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Electrical Testing Association (NETA) or the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.
- B. Testing Agency Qualifications: Certified by NETA or NICET.
  - 1. Testing Agency's Field Supervisor: Certified by NETA or NICET to supervise on-site testing.

1.9 WARRANTY

- A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
  - 1. Warranted Cycle Life for Premium Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

- B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: Two years from date of functional performance testing.

## PART 2 - PRODUCTS

### 2.1 OPERATIONAL REQUIREMENTS

- A. Automatic operation includes the following:

1. Double Conversion, Standard Efficiency:
  - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
  - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
  - c. Power Failure: If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
2. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
3. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
5. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
6. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
7. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
8. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

- B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

- C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
  - 1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
  - 2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
  - 3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.
- D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:
  - 1. Ambient Temperature for Electronic Components: 32 to 104 deg F.
  - 2. Ambient Temperature for Battery: 41 to 95 deg F.
  - 3. Relative Humidity: Zero to 95 percent, noncondensing.
  - 4. Altitude: Sea level to 4000 feet.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- B. UL Compliance: Listed and labeled by an NRTL to comply with UL 1778.
- C. NFPA Compliance: UPS components shall be listed and labeled by an NRTL as suitable for installation in computer rooms according to NFPA 75.
- D. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
  - 1. Inverter is switched to battery source.
  - 2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
  - 3. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
  - 4. Load is 30 percent unbalanced continuously.
- E. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is five minutes.

- F. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus 15 percent from nominal voltage.
- G. Overall UPS Efficiency: Equal to or greater than 95 percent at 100 percent load, 95 percent at 75 percent load, and 94 percent at 25 percent load.
- H. Maximum Energizing Inrush Current: Six times the full-load current.
- I. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.
- J. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.
- K. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.
- L. Limitation of harmonic distortion of input current to the UPS shall be as follows:
  - 1. Description: Rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
  - 2. Description: THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.
- M. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.
- N. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.
- O. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
  - 1. 50 Percent: Plus or minus 3 percent.
  - 2. 100 Percent: Plus or minus 5 percent.
  - 3. Loss of AC Input Power: Plus or minus 1 percent.
  - 4. Restoration of AC Input Power: Plus or minus 1 percent.
- P. Input Power Factor: A minimum of 0.95 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.
- Q. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:
  - 1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
  - 2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.

3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.

- R. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

## 2.3 UPS SYSTEMS

- A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.
- B. 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. APC by Schneider Electric.
  2. Mitsubishi
  3. Eaton.
  4. Liebert; a brand of Emerson Electric Co.
- C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- D. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
- E. Configuration: Multicabinet modular style units.
- F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
- H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.
- J. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.
- K. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.
- L. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

## 2.4 SURGE SUPPRESSION

- A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

## 2.5 RECTIFIER-CHARGER

- A. Description: Voltage source converter, 12-pulse IGBT rectifier.
- B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
- D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
  1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
- E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.
- F. NiCd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F per minute. If the battery reaches 140 deg F prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

## 2.6 INVERTER

- A. Description: Pulse-width modulated, IGBT with sinusoidal output.

## 2.7 CONTROLS AND INDICATIONS

- A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
- C. Indications: Labeled LED.

1. Quantitative indications shall include the following:
  - a. Input voltage, each phase, line to line.
  - b. Input current, each phase, line to line.
  - c. Bypass input voltage, each phase, line to line.
  - d. Bypass input frequency.
  - e. System output voltage, each phase, line to line.
  - f. System output current, each phase.
  - g. System output frequency.
  - h. DC bus voltage.
  - i. Battery current and direction (charge/discharge).
  - j. Elapsed time discharging battery.
2. Basic status condition indications shall include the following:
  - a. Normal operation.
  - b. Load-on bypass.
  - c. Load-on battery.
  - d. Inverter off.
  - e. Alarm condition.
3. Alarm indications shall include the following:
  - a. Bypass ac input overvoltage or undervoltage.
  - b. Bypass ac input over frequency or underfrequency.
  - c. Bypass ac input and inverter out of synchronization.
  - d. Bypass ac input wrong-phase rotation.
  - e. Bypass ac input single-phase condition.
  - f. Bypass ac input filter fuse blown.
  - g. Internal frequency standard in use.
  - h. Battery system alarm.
  - i. Control power failure.
  - j. Fan failure.
  - k. UPS overload.
  - l. Battery-charging control faulty.
  - m. Input overvoltage or undervoltage.
  - n. Input transformer overtemperature.
  - o. Input circuit breaker tripped.
  - p. Input wrong-phase rotation.
  - q. Input single-phase condition.
  - r. Approaching end of battery operation.
  - s. Battery undervoltage shutdown.
  - t. Maximum battery voltage.
  - u. Inverter fuse blown.
  - v. Inverter transformer overtemperature.
  - w. Inverter overtemperature.
  - x. Static bypass transfer switch overtemperature.
  - y. Inverter power supply fault.
  - z. Inverter transistors out of saturation.
  - aa. Identification of faulty inverter section/leg.
  - bb. Inverter output overvoltage or undervoltage.
  - cc. UPS overload shutdown.
  - dd. Inverter current sensor fault.
  - ee. Inverter output contactor open.

- ff. Inverter current limit.
- 4. Controls shall include the following:
  - a. Inverter on-off.
  - b. UPS start.
  - c. Battery test.
  - d. Alarm silence/reset.
  - e. Output-voltage adjustment.
- D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
  - 1. UPS on battery.
  - 2. UPS on-line.
  - 3. UPS load-on bypass.
  - 4. UPS in alarm condition.
  - 5. UPS off (maintenance bypass closed).
- E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

## 2.8 STATIC BYPASS TRANSFER SWITCH

- A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.
- B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.
- C. Input SPD: 80 kA.

## 2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: In separate cabinetry, provide manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
  - 1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
  - 2. Switch shall electrically isolate other UPS components to permit safe servicing.
  - 3. Switch shall electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but shall allow primary power to the UPS for testing.
- B. Comply with NEMA PB 2 and UL 891.
- C. Switch Rating: Continuous duty at rated full-load UPS current.
- D. Mounting Provisions: Internal to system cabinet.
- E. Key interlock with key that is released only when the rectifier-charger and inverter are bypassed by the static bypass transfer switch. Key shall be required to unlock maintenance bypass/isolation switch before switching from open (normal) position to closed position. Lock shall be designed specifically for mechanical and electrical component interlocking.

## 2.10 REMOTE STATUS AND ALARM PANEL

- A. Description: Labeled LEDs on panel faceplate indicating five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
  - 1. Cabinet and Faceplate: Flush mounted to suit mounting conditions indicated.

## 2.11 REMOTE MONITORING

- A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
  - 1. Connectors and network interface units for data transmission via RS-485, Ethernet, or web-based link.
  - 2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.

## 2.12 BATTERY

- 1. System to have 30 minutes of backup battery power
  - 2. Factory assembled in an isolated compartment of UPS cabinet.
  - 3. Mount on two-tier, acid-resistant, painted steel racks.
- B. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units, complete with battery disconnect switch and intercell connectors.
  - 1. Factory assembled in an isolated compartment of UPS cabinet.
  - 2. Mount on two-tier, acid-resistant, painted steel racks.

## 2.13 ISOLATION TRANSFORMER

- A. System to have an output isolation transformer that meets IEEE standard C57.110 for a K13 factor rating.
- B. Transformer to be third party tested and listed.
- C. Shield and windings to be copper.
- D. Provide transformer by ABB, Schnieder or equal.

## 2.14 BASIC BATTERY MONITORING

- A. Description: Continuous, real-time capture of battery performance data.
- B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
- C. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F occurs within the compartment.
- D. Annunciation of Alarms: At UPS control panel and remotely.

## 2.15 SOURCE QUALITY CONTROL

- A. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation. Include the following:
  - 1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
  - 2. Full-load test.
  - 3. Transient-load response test.
  - 4. Overload test.
  - 5. Power failure test.
- B. Observation of Test: Provide 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.
- C. Report test results. Include the following data:
  - 1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
  - 2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
  - 3. List of instruments and equipment used in factory tests.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection if required for coordination with UPS over-current protective device requirements.
- D. Provide a 1/2" scale drawing showing layout of UPS with all the other equipment within the MDF room

### 3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
  - 3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Equipment Mounting: Install UPS on raised floor. Provide pedestals or steel structure to support the weight of the UPS directly from the concrete slab below but at the height equal to the raised floor. Coordinate installation with supplier of the raised floor to make a finished installation. Mounting shall meet seismic requirements of the site.
- F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- G. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

### 3.3 GROUNDING

- A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Separately Derived Systems: If part of a listed power supply for a data-processing room, comply with manufacturer's written instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each battery cell individually.

### 3.5 BATTERY EQUALIZATION

- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified NETA or NICET testing agency to perform tests and inspections.

- B. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:
  - a. Inspect anchorage, alignment, grounding, and required clearances.
  - b. Component type and labeling verification.
  - c. Ratings of installed components.
2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
  - a. Use of low-resistance ohmmeter according to Section 7.22.2.2 of NETA ATS.
  - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or Table 100.12 of NETA ATS.
  - c. Perform thermographic survey according to Section 9 of NETA ATS.
4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.
  - a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 of NETA ATS.
  - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.
  - c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup. Use secondary current injection to test trip functions.
  - d. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.
  - e. Verify operation of charging mechanism.

- f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.
- 8. Test automatic transfer switches.
  - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, according to Section 7.22.3.1 of NETA ATS.
  - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
  - c. Perform a contact/pole-resistance test.
  - d. Verify settings and operation of control devices.
  - e. Calibrate and set all relays and timers according to Section 7.9 of NETA ATS.
  - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
  - g. Perform automatic transfer tests.
    - 1) Simulate loss of normal power.
    - 2) Return to normal power.
    - 3) Simulate loss of emergency power.
    - 4) Simulate all forms of single-phase conditions.
  - h. Verify correct operation and timing of the following functions:
    - 1) Normal source voltage-sensing and frequency-sensing relays.
    - 2) Time delay on transfer.
    - 3) Alternative source voltage-sensing and frequency-sensing relays.
    - 4) Automatic transfer operation.
    - 5) Interlocks and limit switch function.
    - 6) Time delay and retransfer on normal power restoration.
- 9. Test direct current system's batteries.
  - a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
  - b. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
  - c. Verify all charger functions and alarms.
  - d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
  - e. Perform a load test according to manufacturer's published data or IEEE 450.
  - f. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
  - g. Test values.
    - 1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
    - 3) The results of charger functions and alarms shall be according to manufacturer's published data.

- 4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
    - 5) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 6) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
    - 7) Results of load tests shall be according to manufacturer's published data or IEEE 450.
  10. Test communication of status and alarms to remote monitoring equipment.
  11. Contractor shall provide a load bank for UPS testing. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
    - a. Simulate malfunctions to verify protective device operation.
    - b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    - c. Test harmonic content of input and output current at 25, 50, 75, and 100 percent of rated loads.
    - d. Test output voltage under specified transient-load conditions.
    - e. Test efficiency at 50, 75, and 100 percent of rated loads.
    - f. Test remote status and alarm panel functions.
    - g. Test battery-monitoring system functions.
- C. Seismic-restraint tests and inspections shall include the following:
1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
  2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. The UPS system will be considered defective if it does not pass tests and inspections.
- E. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
- F. Prepare test and inspection reports.
- 3.7 PERFORMANCE TESTING
- A. Engage the services of a NETA or NICET qualified power quality specialist to perform tests and activities indicated for each UPS system.
- B. Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period.
1. Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
  2. Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

- C. Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:
1. Current: Each phase and neutral and grounding conductors.
  2. Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
  3. Frequency transients.
  4. Voltage swells and sags.
  5. Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
  6. High-frequency noise.
  7. Radio-frequency interference.
  8. THD of the above currents and voltages.
  9. Harmonic content of currents and voltages above.
  10. Battery cell temperature during charging.
  11. Ambient temperature.
- D. Monitoring and Testing Procedures:
1. Exploratory Period: For the first two days, make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
  2. Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
    - a. Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    - b. Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
    - c. Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
    - d. Using loads and devices available as part of the facility's installed systems and equipment and a temporarily connected portable generator set, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
    - e. Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing; repeat appropriate monitoring and testing to verify success of corrective action.
- E. Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

1. Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
2. Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

F. Monitoring and Testing Assistance by Contractor:

1. Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
2. Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
3. Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
4. Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
5. Engage the services of the UPS manufacturer's factory-authorized service representative for a minimum of two (2) site visits during performance testing operations for repairs, adjustments, and consultations.

G. Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

H. Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in each report:

1. Descriptions of corrective actions performed during monitoring and survey work and their results.
2. Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
3. Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
4. Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
5. Recommendations for operating, adjusting, or revising UPS controls.
6. Recommendations for alterations to the UPS installation.
7. Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
8. Recommendations for power distribution system revisions.
9. Recommendations for adjusting or revising electrical loads, their connections, or controls.

I. Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

### 3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 26 33 53

## SECTION 26 36 00 - TRANSFER SWITCHES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes automatic transfer switches rated 600 V and less, including the following:

1. Bypass/isolation switches.
2. Remote annunciator system.
3. 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.
3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer-authorized service representative.

- B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 018300 "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 QUALITY ASSURANCE

- A. Testing Agency Qualifications:

1. Member company of NETA or NICET.
  - a. Testing Agency's Field Supervisor: Certified by NETA or NICET to supervise on-site testing.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of functional performance testing and acceptance should match the general warrant.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 110.
- D. Comply with UL 1008 unless requirements of these Specifications are stricter.

- E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
  - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
  - 2. Short-time withstand capability for three cycles.
- G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- J. Neutral Terminal: Solid and fully rated unless otherwise indicated.
- K. 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.
- L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed 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 access.
- M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. KOHLER
  - 2. Emerson.
  - 3. ASCO

4. A.B.B. (General Electric)
- B. Comply with Level 1 equipment according to NFPA 110.
- C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
  2. Switch Action: Double throw; mechanically held in both directions.
  3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
  4. Conductor Connectors: Suitable for use with conductor material and sizes.
  5. Material: Tin-plated aluminum.
  6. Main and Neutral Lugs: Compression type.
  7. Ground Lugs and Bus-Configured Terminators: Compression type.
  8. Ground bar.
  9. Connectors shall be marked for conductor size and type according to UL 1008.
- D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
  1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
  2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
  3. Fully automatic break-before-make operation with center off position.
- E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.
- G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- H. Automatic Transfer-Switch Controller Features:
  1. Controller operates through a period of loss of control power.
  2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 600-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is unavailable.

## 2.3 TRANSFER SWITCH ACCESSORIES

### A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
  - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
  - b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
  - c. Draw out Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.

- d. Transition: Provide closed-transition operation when transferring between power sources.
  - e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
  - f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
  - g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
  - h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
  - i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
  - j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
3. Annunciation panel display shall include the following indicators:
  - a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
  - b. Switch position.
  - c. Switch in test mode.
  - d. Failure of communication link.
4. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
  - a. Indicating Lights: Grouped for each transfer switch monitored.
  - b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
  - c. Mounting: Flush, modular, steel cabinet unless otherwise indicated. Mount next to generator remote annunciator.
  - d. Lamp Test: Push-to-test or lamp-test switch on front panel.

C. 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 DOCKING STATION

- A. NEMA 4x Construction
- B. Phase Rotation Meter
- C. Rated the ampacity indicated on drawings at 120/208 volt, 4 wire.
- D. E1016 series male camlok panel mounts with flip covers for portable generator connection.
- E. Provide with one set of color coded cables with connections compatible with camlock on panel and each 50 feet long.
- F. Removable access panels.
- G. Provide cable lugs sized to land cabling from generator and also on the output to the load.
- H. Provide conduit entry from the bottom for both load and input feeders.
- I. 3-pole electronic trip adjustable circuit breaker kirk-key interlocked together and each rated 100%.
- J. Provide with integral GFI receptacles and thermostatically controlled cabinet heater. Contractor to provide all circuitry to make a complete installation.
- K. Manufacturer to Trystar or equal

## 2.5 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.
- B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency 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 TRANSFER SWITCH 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, motor controls 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. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.
- H. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."
- I. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

### 3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified NETA or NICET 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 simultaneously with generator set testing and 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 re-transfer 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.
  - D. Coordinate tests with tests of generator and run them concurrently.
  - E. 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.
  - F. Transfer switches will be considered defective if they do not pass tests and inspections.
  - G. Remove and replace malfunctioning units and retest as specified above.
  - H. Prepare test and inspection reports.
  - I. Infrared Scanning: At tie of functional performance testing, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
    - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - 2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
    - 3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch at 6 months and 11 months after date of functional performance testing.
- 3.4 DEMONSTRATION
- A. Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
  - B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.
  - C. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

## SECTION 26 41 13 - 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.

#### 1.3 ACTION 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. Include roof attachment details, coordinated with roof installation.
  - 5. Calculations required by NFPA 780 for bonding of metal bodies.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Lightning protection cabling attachments to roofing systems and accessories.
  - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
  - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- B. Qualification Data: For Installer.
- C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- D. Field quality-control reports.

#### 1.5 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: UL-listed installer, category OWAY.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.
- B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

### 2.2 MATERIALS

- A. Air Terminals:
  - 1. Copper unless otherwise indicated.
  - 2. 3/8-inch (10-mm) diameter by 12 inches (305 mm) long.
  - 3. Pointed tip.
  - 4. Integral base support.
- B. Air Terminal Bracing:
  - 1. Copper.
  - 2. 1/4-inch (6-mm) diameter rod.
- C. Class 1 Main Conductors:
  - 1. Stranded Copper: 57,400 circular mils in diameter.
- D. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.
- E. Ground Loop Conductor: Stranded copper.
- F. Ground Rods:
  1. Material: Solid copper.
  2. Diameter: 5/8 inch.
  3. Rods shall be not less than 120 inches long.
- G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed installations in UL 96A.
  1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
  2. Install conduit where necessary to comply with conductor concealment requirements.
  3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

#### 3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
  1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

### 3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

### 3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
  1. Perform inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

END OF SECTION 26 41 13

## SECTION 26 43 13 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
  - 1. Section 262413 "Switchboards" for factory-installed SPDs.
  - 2. Section 262416 "Panelboards" for factory-installed SPDs.

#### 1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs 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 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCESUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 1.
  - a. Integral disconnect switch.
  - b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
  - c. Indicator light display for protection status.
  - d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - e. Surge counter.
- B. Comply with UL 1283.

- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V.
  - 2. Line to Ground: 1500 V for 480Y/277 V.
  - 3. Line to Line: 2500 V for 480Y/277 V.
- E. SCCR: Equal or exceed 200 kA.
- F. Inominal Rating: 20 kA.

## 2.3 PANEL SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 1.
  - 1. Include LED indicator lights for power and protection status.
  - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
  - 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. Comply with UL 1283.
- D. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V.
  - 2. Line to Ground: 1500 V for 480Y/277 V.
  - 3. Line to Line: 2500 V for 480Y/277 V.
- E. SCCR: Equal or exceed 200 kA.
- F. Inominal Rating: 20 kA.

## 2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

## 2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install SDDs within panel EDP, ECI and ECP enclosure.
- C. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- D. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- E. Use crimped connectors and splices only. Wire nuts are unacceptable.
- F. Wiring:
  - 1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
  - 2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

#### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
  - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
  - 2. Inspect anchorage, alignment, grounding, and clearances.
  - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

#### 3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

#### 3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 43 13

## SECTION 26 51 19 - 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. Downlight.
  - 2. Linear industrial.
  - 3. Recessed, linear.
  - 4. Strip light.
  - 5. Suspended, linear.
- B. Related Requirements:
  - 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
  - 2. Section 260936 "Modular Dimming Controls" for architectural dimming systems and for LED dimming controls with dimming ballasts specified in interior lighting Sections.

#### 1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Arrange in order of luminaire designation.

2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
  - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
  - 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.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Contractor shall provide 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 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. 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 luminaire.
- E. Product Test Reports: For each type of luminaire, for tests performed by a qualified testing agency.
- F. 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 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. 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.
- 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. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
  1. Obtain Architect's approval of luminaires in mockups before starting installations.
  2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
  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. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

#### 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.
- B. Warranty Period: Five year(s) from date of functional performance testing acceptance.

## 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 3000 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, 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 DOWNLIGHT.

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

1. Cooper Lighting, an Eaton business.
2. Focal Point LLC.
3. GE Lighting Solutions.
4. Lightolier; a Philips group brand.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.

- B. Nominal Operating Voltage: 120 V ac.

- C. Lamp:

1. Minimum 1000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. CRI of 80. CCT of 4100 K.
4. Rated lamp life of 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:
  - a. Bulb shape complying with ANSI C78.79.
  - b. Lamp base complying with ANSI C81.61.
8. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

- D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear painted finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

- E. 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.

- F. Diffusers and Globes:

1. Fixed lens.
2. Medium light distribution.
3. Diffuse glass Clear glass Prismatic acrylic.
4. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
5. Glass: Annealed crystal glass unless otherwise indicated.

6. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. Recessed luminaires shall comply with NEMA LE 4.

2.4 LINEAR INDUSTRIAL.

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

1. Cooper Lighting, an Eaton business.
2. GE Lighting Solutions.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. Lightolier; a Phillip Group Brand

B. Lamp:

1. Minimum allowable efficacy of 80 lm/W.
2. CRI of minimum 80. CCT of 4100 K.
3. Rated lamp life of 50,000 hours to L70.
4. Dimmable from 100 percent to 0 percent of maximum light output.
5. Internal driver.
6. User-Replaceable Lamps:
  - a. Bulb shape complying with ANSI C78.79.
  - b. Lamp base complying with ANSI C81.61.
7. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear painted finish.

D. Housing and Heat Sink Rating:

1. Class 1, Division 2 Group(s) A B C and D.
2. NEMA 4X.
3. IP 54.
4. IP 66.
5. Marine and wet locations.
6. CSA C22.2 No 137.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Prismatic glass Diffuse glass Clear glass Prismatic acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

G. With integral mounting provisions.

H. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

2.5 RECESSED, LINEAR.

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 Lighting, an Eaton business.
2. GE Lighting Solutions.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. Lightolier

B. Nominal Operating Voltage: Universal voltage of 120V and/ or 277 volts.

C. Lamp:

1. Minimum 1,500 lm.
2. CRI of minimum 80. CCT of 4100 K.
3. Rated lamp life of 50,000 hours to L70.
4. Dimmable from 100 percent to 0 percent of maximum light output.
5. Internal driver.
6. User-Replaceable Lamps:
  - a. Bulb shape complying with ANSI C78.79.
  - b. Lamp base complying with ANSI C81.61.
7. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear painted finish.
3. With integral mounting provisions.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are de-

signed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Diffusers and Globes:

1. Prismatic glass Diffuse glass Clear glass Prismatic acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. NEMA LE 4.

2.6 STRIP LIGHT.

A. Nominal Operating Voltage: 120 V ac.

B. Lamp:

1. Minimum 750 lm.
2. CRI of minimum 80. CCT of 4100 K.
3. Rated lamp life of 50,000 hours to L70.
4. Dimmable from 100 percent to 0 percent of maximum light output.
5. Internal driver.
6. User-Replaceable Lamps:
  - a. Bulb shape complying with ANSI C78.79.
  - b. Lamp base complying with ANSI C81.61.
7. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping of luminaire without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Prismatic glass Diffuse glass Clear glass Prismatic acrylic.

2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 SUSPENDED, LINEAR

A. Nominal Operating Voltage: Universal 120V/277V.

B. Lamp:

1. Minimum 1,500 lm.
2. CRI of minimum 80. CCT of 4100 K.
3. Rated lamp life of 50,000 hours to L70.
4. Dimmable from 100 percent to 0 percent of maximum light output.
5. Internal driver.
6. User-Replaceable Lamps:
  - a. Bulb shape complying with ANSI C78.79.
  - b. Lamp base complying with ANSI C81.61.
7. Lens Thickness: At least 0.125-inch overall minimum thickness unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. Prismatic glass Diffuse glass Clear glass Prismatic acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

3. UL Listing: Listed for damp location.

## 2.8 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 A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for sheet steel.

### C. Stainless Steel:

1. Manufacturer's standard grade.
2. Manufacturer's standard type, ASTM A 240/240 M.

### D. Galvanized Steel: ASTM A 653/A 653M.

### E. Aluminum: ASTM B 209.

## 2.9 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.

## 2.10 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 30 degree swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 1/4"-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. Only when approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

### 3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and relamping.
  - 3. Provide support for luminaire without causing deflection of ceiling or wall.
  - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaires:
  - 1. Secured to outlet box.
  - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
  - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaires:
  - 1. Attached to structural members in walls Attached to a minimum 20 gauge backing plate attached to wall structural members.
  - 2. Do not attach luminaires directly to gypsum board.
- G. Suspended Luminaires:
  - 1. Ceiling Mount:
    - a. Two 5/32-inch-diameter aircraft cable supports 10 feet in length.
  - 2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.

3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. 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.

### 3.6 STARTUP SERVICE

- A. Comply with requirements for startup specified in Section 260923- "Lighting Control Devices"; 260936- "Modular Dimming Controls".

### 3.7 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 26 51 19

## SECTION 26 52 13 - 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. Emergency lighting units.
  - 2. Exit signs.
  - 3. 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 emergency lighting unit, exit sign, and emergency lighting support.
  - 1. Include data on features, accessories, and finishes.
  - 2. Include physical description of the unit and dimensions.
  - 3. Battery and charger for light units.
  - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
  - 5. 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. Photometric data for remaining luminaires and signs shall be certified by manufacturer.

- 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. Samples: For each product and for each color and texture specified.
- D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.
- E. Samples for Verification: For each type of luminaire.
  - 1. Include Samples of luminaires and accessories to verify finish selection.
- F. 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: Contractor shall provide 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. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.
- F. 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 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
  3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
  4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

#### 1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- C. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
  2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

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. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

#### 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.
  1. Warranty Period: Two year(s) from date of Substantial Completion.
- B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
  1. Warranty Period for Emergency Power Unit Batteries: Five years from date of functional performance testing acceptance. Full warranty shall apply for first year and prorated warranty for the remaining four years.
  2. Warranty Period for Self-Powered Exit Sign Batteries: Two years from date of functional performance testing acceptance. Full warranty shall apply for the entire warranty period.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

#### 2.2 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, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.

- D. Comply with NEMA LE 4 for recessed luminaires.
- E. Comply with UL 1598 for fluorescent luminaires.
- F. Lamp Base: Comply with ANSI C81.61.
- G. Bulb Shape: Complying with ANSI C79.1.
- H. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.
  - 1. Emergency Connection: Operate one LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
  - 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
  - 3. Nightlight Connection: Operate lamp in a remote luminaire continuously.
  - 4. Battery: Sealed, maintenance-free, lead-acid type.
  - 5. Charger: Fully automatic, solid-state, constant-current type.
  - 6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
  - 7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
  - 8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 9. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
  - 10. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

## 2.3 EMERGENCY LIGHTING

- A. General Requirements for Emergency Lighting Units: Self-contained units.
- B. Emergency Lighting Unit:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cooper Lighting, an Eaton business.
    - b. GE Lighting Solutions.
    - c. Lithonia Lighting; Acuity Brands Lighting, Inc.
  - 2. Emergency Lighting Unit: as indicated on Interior Luminaire Schedule.
  - 3. Operating at nominal voltage of 120 V ac.
  - 4. Wall with universal junction box adaptor.

5. UV stable thermoplastic housing.
6. Two LED lamp heads.
7. Internal emergency power unit.

## 2.4 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cooper Lighting, an Eaton business.
    - b. Lithonia Lighting; Acuity Brands Lighting, Inc.
    - c. Philips Lighting Company.
  2. Operating at nominal voltage of 120 V ac.
  3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
  4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
  5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
  6. Master/Remote Sign Configurations:
    - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
    - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

## 2.5 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. Diffusers and Globes:
  1. Prismatic glass Diffuse glass Clear glass Prismatic acrylic.
  2. Glass: Annealed crystal glass unless otherwise indicated.

3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. Clear painted finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

## 2.6 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.

## 2.7 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 A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

## 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. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. 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 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 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, batteries, 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 26 52 13

## SECTION 26 56 19 – 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 Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
  - 2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

#### 1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.
  - 1. Arrange in order of luminaire designation.
  - 2. Include data on features, accessories, and finishes.
  - 3. Include physical description and dimensions of luminaire.
  - 4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
    - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    - 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. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.
- D. Product Schedule: For luminaires and lamps.
- E. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports.

## 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 equipment and 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.
- 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. Product Test Reports: For each luminaire, for tests performed by a NETA or NICET qualified testing agency.
- F. Source quality-control reports.
- G. 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 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
  2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
  3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
  4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

#### 1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. 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.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

#### 1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

#### 1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures, including luminaire support components.
    - b. Faulty operation of luminaires and accessories.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
  - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- 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. Lamp base complying with ANSI C81.61.
- F. Bulb shape complying with ANSI C79.1.
- G. CRI of minimum 80. CCT of 4100 K.
- H. L70 lamp life of 50,000 hours.
- I. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- J. Internal driver.
- K. Nominal Operating Voltage: 120 V ac.
- L. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.
- M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

## 2.3 LUMINAIRE TYPES

- A. Building Mounting
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cooper Lighting, an Eaton business.
    - b. Deco Lighting.
    - c. GE Lighting Solutions.
    - d. Lightolier; a Philips group brand.
    - e. Lithonia Lighting; Acuity Brands Lighting, Inc.
  - 2. Housings:
    - a. Extruded-aluminum housing and heat sink.
    - b. Clear painted finish.

## 2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum. 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. Diffusers and Globes:
  - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - 2. Glass: Annealed crystal glass unless otherwise indicated.
  - 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. 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.
- G. 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.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
  - 1. Label shall include the following lamp characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. Lamp diameter, shape, size, wattage and coating.
    - c. CCT and CRI for all luminaires.

## 2.5 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

- C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
  - 2. 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.
- D. 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, and 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 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.
- 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.

### 3.3 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

### 3.4 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. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 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.

### 3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photo-cell relays.

### 3.7 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 26 56 19

## SECTION 270500 - COMMON WORK RESULTS – COMMUNICATIONS

### 1.1 STIPULATION

- A. The specification sections “General Conditions of Contract”, “Special Conditions” and “Division 1 – General Requirements” form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.
- B. Should there be any conflict in requirements the more stringent shall apply.
- C. Should there be any conflict between specifications and/or drawings the contractor shall verify the intent with the design team. The design intent shall be considered the basis of design, and thus the contracted scope of work.

### 1.2 SUMMARY

- A. The Work of this Section includes all labor, materials and equipment to provide the following Communications System components:
  - 1. Utility Services Coordination
  - 2. Interior Pathways and Interior Pathway Coordination
  - 3. Exterior Pathways and Exterior Pathway Coordination
  - 4. Testing
  - 5. Vibration and Seismic Controls
  - 6. Identification and Documentation

### 1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Contractor shall comply with the most recent edition of the referenced Codes and Standards, unless noted otherwise.
- C. Harris Site Grounding and Lightning Protection Guidelines
- D. Motorola R56 – Standards and Guidelines for Communications Sites, latest issue
- E. NFPA 70 National Electrical Code
- F. ANSI/TIA-568-E - Series - Generic Telecommunications Cabling for Customer Premises
- G. ANSI/TIA 569-E Telecommunications Pathways and Spaces
- H. ANSI/TIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
- I. ANSI/TIA-607-D Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- J. ANSI/TIA-942-B Telecommunications Infrastructure Standard for Data Centers
- K. ANSI/BICSI-002-2019 – Data Center Design and Implementation Best Practices

- L. BICSI Telecommunications Distribution Methods Manual (TDMM), most recent issue.
- M. Section 260500 General Requirements for Electrical Work
- N. Section 260533 Raceways and Boxes for Electrical Systems
- O. Section 260526 Grounding and Bonding
- P. Section 262726 Wiring Devices and Wall Plates
- Q. Section 271000 Structured Cable System
- R. Section 270508 Pathway for Communications Systems
- S. Section 270526 Grounding and Bonding for Communications Systems
- T. Section 271116 Equipment Rooms and Fittings - Communications

#### 1.4 SUBMITTALS

- A. Submit product specification sheets for review and approval in accordance with the Division 01 Requirements.
- B. Submit product data for each product specified in this Section.
- C. Submit qualifications for the Contractor's Supervisor/Foreman responsible for installation of the communications cable system.
- D. Submit samples for review and approval in accordance with Division 1 Requirements.
- E. Submit certificates of calibration for all test equipment.

#### 1.5 COORDINATION

- A. Coordinate exact requirements for Utility raceway and hand-hole installation with all Service Providers prior to start of installation.
- B. Coordinate all raceway locations at utility poles and utility vaults with all Service Providers prior to start of installation.
- C. Coordinate specific marking and tagging requirements for utility service entrance raceways with all Service Providers prior to start of installation.
- D. Coordinate the location of all building entrance raceways with the General Contractor prior to start of installation.
- E. Coordinate the location of all outlets with the Architect, End Users and the work of other trades prior to the start of rough-in.
  - 1. Contractor shall be especially careful in coordinating rough-ins for outlets and boxes feeding modular furniture systems.
  - 2. Outlets and boxes feeding modular furniture systems shall not be blocked by the modular furniture system after furniture installation.
- F. Coordinate the location and elevation of the transmission line entry port system(s) with the General Contractor prior to the General Contractor ordering precast structures for the Radio Room or prior to the start of masonry work at the Radio Room as applicable.
- G. Coordinate final labeling and identification system with End Users prior to start of rough-in.

1.6 QUALITY ASSURANCE

- A. Quality assurance requirements as defined in Division 01 requirements and as follows:
  - 1. All products shall be Listed for the specific application intended as part of this Work.
  - 2. All products shall be Listed and Labeled by UL or another Nationally Recognized Test Laboratory (NRTL).
- B. At a minimum, the Contractor's Supervisor/Foreman, responsible for this installation of the Work of this Section shall be trained by the manufacturer for installation of the products installed as part of the Work.
- C. Installations shall comply with the requirements of the standards listed above.

1.7 DELIVERY, STORAGE AND HANDLING

- A. All products shall be delivered to site in the original manufacturer's packaging, distributors packaging or other packaging suitable for protection of the materials.
- B. All products stored off-site and on-site shall be maintained in manner to protect the materials from weather, corrosion or damage.
- C. All products shall be stored in a secure location under the direct control of the Contractor.
- D. All products shall be handled as recommended by the Manufacturer.
- E. Any products exhibiting evidence of damage, corrosion or defect shall be removed from site and replaced at no additional cost to the End Users.

1.8 TRAINING (NOT USED)

1.9 AS-BUILT RECORD DOCUMENTS

- A. Following completion of the installation and as otherwise noted, provide a complete set of as-built documents including, but not limited to the following:
  - 1. Complete Record Drawings: Showing locations, size, length and configuration of all components, devices and equipment.
    - a. Detailed as-built locations of outlets and equipment
    - b. Detailed labeling of all outlets and cables
    - c. Detailed wiring diagrams of all installed systems
    - d. Typical wiring diagrams of Category Rated cable system components
  - 2. Final Inspection and Test Report:
    - a. Test procedure used.
    - b. Record of any failed tests and corrective action taken.
    - c. Final test reports

1.10 WARRANTY

- A. Provide a warranty as required by Division 01 and as indicated herein.

- B. Provide a minimum 25-year extended performance warranty on all Category Rated cable infrastructure provided as part of this project.
- C. Provide a minimum 15-year extended component warranty on all structured cable system components not covered under the system performance warranty.

1.11 MAINTENANCE SERVICES (NOT USED)

1.12 SPARE PARTS (NOT USED)

1.13 DESIGN BASIS MANUFACTURERS

- A. Products from the following manufacturers generally conform to the specific design basis for the Work. Subject to product compliance with the requirements of the Construction Documents, acceptable Manufacturer's include, but are not limited to:
  - 1. Hubbell Electrical
  - 2. Leviton
  - 3. Panduit
  - 4. Carlon Industries
  - 5. DuraLine
  - 6. Endot Industries
  - 7. Chatsworth Products, Inc. (CPI)
  - 8. Rittal
  - 9. Cooper/B-Line
  - 10. Hoffman Enclosures
  - 11. Hammond Manufacturing
  - 12. Brady
  - 13. Tech Products, Inc.
- B. All products provided as part of this Work shall be Listed for their intended use by a Nationally Recognized Testing Laboratory (NRTL).

1.14 UTILITY SERVICE ENTRANCE PATHWAYS

- A. Contractor shall provide Schedule 40 raceways from the utility pole to the building entrance facility as indicated on the Drawings.
- B. Contractor shall provide raceways and hand-holes for utility service entrances as indicated on the Drawings, as required to maintain bends between pull points to 270 degrees or less, and as required to maintain a maximum pull length of 600 feet.
- C. All PVC raceways shall be provided with RMC conduit and swept 90 degree bends at utility poles, building entrance locations and where entering the building through the slab.
- D. All bends in metal conduits shall be made with the largest bending shoe available.

- E. All bends in non-metallic conduit shall be made with a box heater and swept to as large a radius as possible for the bend.
- F. Factory made elbows shall not be used.
- G. Conduits under paved driving and roadway surfaces shall be concrete encased.

#### 1.15 EXTERIOR PATHWAYS

##### A. Conduit

- 1. Contractor shall provide Schedule 40 raceways for exterior pathways as indicated on the Drawings.
- 2. Raceways shall be provided as required in this Section.
- 3. Contractor shall provide raceways and hand-holes for exterior pathways as indicated on the Drawings, as required to maintain bends between pull points to 180 degrees or less, and as required to maintain a maximum pull length of 600 feet.
- 4. All PVC raceways shall be provided with RMC conduit and swept 90 degree bends at utility poles, building entrance locations and where entering the building through the slab.
- 5. All bends in metal conduits shall be made with the largest bending shoe available.
- 6. All bends in non-metallic conduit shall be made with a box heater and swept to as large a radius as possible for the bend.
- 7. Factory made elbows shall not be used.
- 8. Conduits under paved driving and roadway surfaces shall be concrete encased.

##### B. Innerduct

- 1. Design Basis Product: Carlon Industries or approved equal.
- 2. Contractor shall provide outside plant rated innerduct in exterior conduits as shown on the Drawings and as otherwise indicated in the Documents.
- 3. Material: High density polyethylene (HDPE)
- 4. Dimensions: Sizes indicated on the drawings indicate the minimum inside diameter of the innerduct to be provided.
- 5. Construction:
- 6. Exterior Wall: Smooth
- 7. Interior Wall: Ribbed
- 8. Provide factory installed 1200 lb. tensile braided pull tape in each innerduct, tie off at both ends of innerduct for future use.
- 9. Provide factory installed permanent silicone lubricant in all innerducts.
- 10. Innerduct sizes and quantities shall be as indicated on drawings.

##### C. Exterior Pedestal Enclosure

- 1. Design Basis Product: Hoffman ComLine NEMA Type 4x enclosure or approved equal.
- 2. For installation on a pipe/pole mount pedestal support.
- 3. Material:
- 4. Body: 0.080 in. thick Type 5052-H32 aluminum

5. Cover: 0.080 in. thick Type 5052-H32 aluminum
6. Dimensions: 24 inches high x 24 inches wide x 8 inches deep, nominal
7. Construction: Welded joints, ground smooth.
8. Solid cover, hinged along the side edge.
9. NEMA 4X rating
10. Weather tight gasketed cover.
11. Color: Light gray
12. Provide with key lock latching cover.
13. Provide with padlock kit.
14. Provide with internal panel.
15. Motorola R56 compliant secondary ground bus (SBB)
16. Provide with a solar shield top.
17. Provide with pole mount bracket
18. Provide a concrete embedded, concrete filled 4" RMC base mounting pole.
19. Provide the enclosure with a heater and thermostat
  - a. Design Basis Products:
    - i. Heater: Hoffman/McLean Semiconductor Heater, or approved equal.
  - b. 30 Watt, 1.2A, 120VAC
    - i. Thermostat: Hoffman Electronic Hygrotherm, or approved equal.
  - c. Low temperature set point at 50 degrees Fahrenheit
  - d. High humidity set point at 65 percent Relative Humidity
20. Provide with other accessories as required and as indicated on the Drawings.
21. Provide with electrical receptacles as shown on the Drawings.
22. Provide with a custom wire or metal bracket to support optical fiber converters and fiber splice trays as shown on the Drawings. Optical fiber converters will be furnished by the End Users.
  - a. The custom bracket shall be fabricated to mount the optical fiber converters as indicated on the drawings.
  - b. The design basis optical fiber converter has the following dimensions: 3-7/8 inch wide x 3-1/2 inch wide x 1 inch deep as shown on the drawings.
  - c. Sufficient space shall be included in the box to house a End Users provided power strip and four power supplies.
    - i. The individual power supplies are: 1-3/4 inches wide x 2-3/4 inches high x 1-1/4" deep.
23. Modify the enclosure to accept a NEMA 4X connector access panel mounted to the face of the box.
24. Coordinate exact placement of boxes and conduits with the General contractor prior to rough-in.

25. Provide with other accessories as required and as indicated on the Drawings.

#### 1.16 INTERIOR PATHWAYS

- A. Conduit raceways for telecommunications outlets shall be as specified in Section 16111 Conduits, Section 16130 Boxes, and as specified in this Section. Unless noted otherwise:
  1. Conduit raceways for telecommunications outlets to receive Category 6A cables shall be 1-1/4" minimum.
  2. Conduit raceways for telecommunications outlets to receive Category 6 or lower cable shall be 1" minimum.
  3. Conduit raceways for A/V outlets shall be 1-1/4" minimum.
  4. Conduit raceways for CATV outlets shall be 1" minimum.
- B. Cable Tray
  1. Design Basis Product: Cooper B-Line FlexTray Series, or approved equal.
  2. For installation as the primary telecommunications cable support system above accessible ceilings and below accessible floors.
  3. Material: 0.196" (5mm) minimum diameter steel wire.
  4. Construction: Welded on 2" x 4" intersections.
  5. Finish: Zinc plated.
  6. Provide in 4-inch tray depths as indicated on the Drawings.
  7. Provide in 22-inch cable tray widths as indicated on the Drawings.
  8. Provide with trapeze type hanger bars for installation above accessible ceilings. Center hung supports will not be accepted.
  9. Provide with stands, cantilever stands, under-floor stands and pedestal clamp support systems for installation below accessible floors.
  10. Provide with minimum 3/8" threaded rods, bolts and hardware for attaching overhead cable tray to building structure.
  11. Provide with u-channel supports as required to span supports under duct work and similar obstructions. Cable tray supported from duct work or the work of other trades will not be accepted.
  12. Make all field cuts, bends, transitions and junctions to maintain:
    - a. A 24" minimum inside bend radius at changes in direction for cable trays 12" wide and wider above accessible ceiling.
    - b. A 12" minimum inside bend radius at changes in direction for 6-inch cable trays above accessible ceiling.
  13. Cable trays below access floor shall be installed with square corners and flexible radius shields to maintain minimum cable bend radius around corners.
  14. Provide with all tray section splices, mounting hardware, fasteners, anchors, etc. for a complete installation.
  15. Provide with radius cable drop outs between non-continuous sections of cable tray at vertical transitions.

16. Provide with bonding straps between non continuous sections of cable tray.
17. Provide with cable tray label holder for mounting warning labels on cable tray.
18. Provide each cable tray wall penetration with acoustic batting, completely filling all voids and gaps in the penetration.

C. J-Hooks

1. Not for use for communications and signaling wiring in Communications Center, per NFPA 1221, Section 5.5.
2. Design Basis Product: Erico Caddy CatLinks Wide Base J-Hooks, or approved equal
3. Designed for support of both Category 6 and Category 6A and higher cables.
4. Construction: Galvanized steel
5. Provide 1-inch, 2-inch, 3-inch and 4-inch J-hooks as required by cable quantity.
6. Wire bail to hold cables in J-hooks after installation.
7. Provide with hook trees, mounting brackets, threaded rod, and accessories for a complete installation.
8. J-Hooks shall be installed at random intervals approximately 48" apart.
9. Do not bundle more than 24 UTP cables together when PoE will be used.
10. Provide J-hooks as required to maintain the maximum cable fill as follows:
  - a. 1" J-hook: 7 cables
  - b. 2" J-hook: 24 cables

D. Telecommunications Outlet Boxes

1. Boxes for telecommunications outlets shall be as specified in this section.
2. Unless noted otherwise, boxes for telecommunications wall, ceiling and above ceiling outlets to receive Category 6A cables shall be 5" x 5" x 2-3/4", minimum.
3. Unless noted otherwise, boxes for telecommunications wall, ceiling and above ceiling outlets to receive only Category 6 or lower cable shall be 4-11/16" x 4-11/16" x 2-1/8", minimum.
4. Unless noted otherwise, boxes for audio/video (A/V) devices shall be 6" x 6" x 3-1/2", minimum.
5. Masonry boxes shall not be used for telecommunications and A/V outlets unless approved in advance by the Design Team.
6. The termination chamber for telecommunications outlets in in-slab boxes, poke-through boxes and raised access floor boxes shall provide a minimum of 50 cubic inches of space behind the device plate for every four telecommunications cables to be installed in the box.
7. Above ceiling mount outlet boxes shall be mounted to building structure with angle brackets and beam clamps or other demountable attachment method to allow for relocation of outlet.
8. Ceiling mount outlet boxes shall be mounted to accessible ceiling grid or GWB ceiling supports with tile bridges or as approved for box, device and equipment support.

E. Interior Wall Mount Enclosures

1. Design Basis Product: Hoffman, or approved equal.

2. For housing optical fiber converters, fiber cable terminations, media connections and audio multi-box connections.
3. Material:
  - a. Body: 16 gauge steel
  - b. Cover; 16 gauge steel
4. Dimensions: 36 inches high x 24 inches wide x 8 inches deep, nominal
5. Solid cover, modified to mount front panel audio and video connectors
6. NEMA 1 rated
7. Color: As directed by Architect.
  - a. Baked powder coat or epoxy paint.
  - b. Enclosure cover shall be painted after all front panel modifications.
8. Provide with key lock, hinged latching cover.
9. Provide with internal panel.
10. Motorola R56 compliant secondary ground bus (SBB)
11. Provide with other accessories as required and as indicated on the Drawings.
12. Provide with electrical receptacles as shown on the Drawings.
13. Provide with a custom wire or metal brackets to support optical fiber converters and fiber splice trays as shown on the Drawings. Optical fiber converters will be furnished by the End Users.
  - a. The custom brackets shall be fabricated to mount the optical fiber converters as indicated on the drawings.
  - b. The design basis optical fiber converter has the following dimensions: 3-7/8 inch wide x 3-1/2 inch wide x 1 inch deep as shown on the drawings.
  - c. Sufficient space shall be included in the box to house a End Users provided power strip and four power supplies.
    - i. The individual power supplies are: 1-3/4 inches wide x 2-3/4 inches high x 1-1/4" deep.
14. Provide singlemode angled polished fiber connectors spliced to the installed fiber cables.
15. Coordinate exact placement of boxes and conduits with the General contractor prior to rough-in.
16. Coordinate exact configuration of panel mount connectors, mounting brackets, power supplies and equipment with the End Users prior to fabrication and assembly.

#### 1.17 SEISMIC AND VIBRATION CONTROLS

- A. Contractor shall provide bracing and support structures for telecommunications cabinets, racks, raceways and equipment in accordance with Section addressing Seismic Controls for Electrical Work.

## 1.18 IDENTIFICATION AND DOCUMENTATION

### A. Detectable Warning Tape

1. Contractor shall provide detectable warning tape at 12 inches below finished grade above all conduits for telecommunications cables and direct buried telecommunications cables.
2. Provide warning tape as specified in Telecommunications Outside Plant, and as specified in this Section.
3. Warning tape installed above communications cables and conduits shall be orange.
4. Text: "Warning: Underground Communications Lines", or as approved.

### B. Cable Labels

#### 1. Interior Cable Labels

- a. Contractor shall provide permanent machine printed labels on all interior cables.
- b. Material: Polyester
- c. Configuration: Self laminating, white field, clear laminate.
- d. Size: One inch wide field, minimum
- e. Lettering: 1/8" high, Arial or similar non-serif font.
- f. Text: Cable identification as indicated on Drawings and as coordinated with End Users.

#### 2. Exterior Cable Labels

- a. Provide permanent embossed or molded labels on all exterior cables.
- b. Material: UV stabilized polyolefin plastic or as approved
- c. Size: 1.5 inch high individual alpha-numeric symbols
- d. Lettering: 1 inch high, injection molded
- e. Color:
  - i. Black on orange field – general communications
  - ii. Black on orange field - multimode fiber
  - iii. Black on yellow field – singlemode fiber
- f. Text: Cable identification as indicated on Drawings and as coordinated with End Users.
- g. Provide with poly tag holders of sufficient length to hold all identification characters.
- h. Attach to cables with UV stabilized cable ties rated for use in outside plant applications or stainless steel straps.

### C. Cable Warning Labels

1. Provide cable warning labels at building entrances and in all hand holes.
2. Communications Cable Labels
  - a. Material: UV stabilized polyolefin plastic or as approved
  - b. Size: 2 inch x 4 inch, minimum
  - c. Lettering: ½ inch high, injected molded or embossed

- d. Color: Black on orange field
    - e. Text: "Caution: Telecommunications Cable", or as approved
  - 3. Fiber Optic Cable Labels
    - a. Material: UV stabilized polyolefin plastic or as approved
    - b. Size: 2 inch x 4 inch, minimum
    - c. Lettering: ½ inch high, injected molded or embossed
    - d. Color:
      - i. Multimode Fiber Cable: Black on orange field
      - ii. Singlemode Fiber Cable: Black on yellow field
    - e. Text: "Caution: Fiber Optic Cable", or as approved
    - f. Attach to cables with UV stabilized cable ties rated for use in outside plant applications or stainless steel straps
- D. Cabinet and Rack Labels
  - 1. Provide non-conductive laminated plastic engraved labels to identify all cabinets, racks, consolidation points and wireless access point locations.
  - 2. Material: Two layer laminate, white lettering on black field, unless noted otherwise.
  - 3. Size: 1" high x 4" wide, minimum
  - 4. Lettering: ½" engraved, unless noted otherwise.
  - 5. Text: In accordance with the approved labeling scheme, as indicated on Drawings and as coordinated with End Users.
  - 6. Label Location: Upper left hand corner of front face of cabinet or rack as coordinated with End Users, and as otherwise noted.
  - 7. Attach to cabinet or rack with screws or permanent double sided transfer adhesive suitable for the mounting surface.
  - 8. Refer to Section 16711, Structured Cable System for label placement for consolidation points and wireless access point outlets.
- E. Cable Tray Labels
  - 1. Provide machine printed cable tray labels at 10 foot intervals on all cable tray and runway.
  - 2. Material: Adhesive backed poly or embossed poly material.
  - 3. Size: Two inches high x 12" inch length, minimum
  - 4. Lettering: Minimum ½" high lettering, machine printed or embossed
  - 5. Text: "Warning: Do not use as walkway, ladder or support for personnel. Use only as mechanical support for cables, tubing and raceways."
  - 6. Attach to cable tray and runway with permanent adhesive, cable ties or stainless steel straps.
- F. Outlet Labels
  - 1. Contractor shall provide machine printed labels on the faceplates of all telecommunications outlets.
  - 2. Material: Adhesive backed polyester, or as approved.

3. Size:  $\frac{3}{4}$  inch high x 1 inch wide, nominal, as required by outlet type.
4. Lettering: 1/8" high, Arial or similar non-serif font.
5. Text: Outlet identification as indicated on Drawings and as coordinated with End Users.
6. Label Location: As indicated on the Drawings.
7. Attach to faceplate with adhesive backing.
8. Legibly write the outlet identification inside the faceplate with indelible permanent marker.

G. Conduit Labels

1. Contractor shall clearly mark all conduits with the respective outlet number or from/to designation within six inches of the conduit termination or connection point.
2. Conduits above accessible ceilings and in equipment rooms shall be clearly marked with an indelible permanent marker or machine printed label.
3. Conduits in exposed areas shall be marked with a machine printed label.

## PART 2 - EXECUTION

### 2.1 UTILITY SERVICES ENTRANCE RACEWAYS

- A. Utility service entrance raceways, hand holes, man holes, etc. shall be installed in strict compliance to the Service Provider's requirements.
- B. Coordinate exact requirements for utility service entrance raceways with individual service providers.
- C. Installation shall be as specified as follows:
  1. Conduit bodies shall not be installed in conduit runs for telecommunications utility service entrance cables. Provide properly sized pull boxes at locations require the use of a conduit body for pulling cable. Pull boxes shall be sized to support cable minimum bend radius in accordance with the telecommunications service provider requirements.
  2. Conduits for telecommunications utility service cables shall be installed so that not more than 2 quarter bends (180 degrees) between pull points.
  3. Conduits for telecommunications utility service entrance conduits shall be turned up at utility pole locations in rigid steel conduit (RGS) to a minimum of three feet above finished grade.
  4. Rod, swab and perform a mandrel test on all exterior conduits following backfill and concrete encasement to verify that the conduit has not been damaged during installation. Remove and replace any conduits exhibiting damage at no additional cost to the Owner or End Users.
  5. Install temporary caps on all exterior conduits to prevent ingress of water and foreign materials after mandrel testing and before installation of innerducts and cables.
  6. Provide a 1200 lb. test pull tape in each telecommunications conduit and innerduct.
    - a. Pull tapes shall not be installed with cables.
    - b. Contractor shall remove pull tapes from conduits after cable installation, fish or rod the conduit/duct and install a new pull tape after all cables are installed.

7. Seal all conduits and raceways penetrations with duct seal (outside conduits) and mechanical duct plugs (inside conduits).
  - a. Size duct plugs for proper seal around installed cables.
  - b. Coordinate installed cable sizes with service providers.
8. Provide firestop systems around all pathways through and floor wall penetrations in all fire rated structures.
9. Provide sealed fire stop systems at all pathways through wall and floor penetrations in the equipment room and all spaces equipped with a clean agent fire suppression system.
  - a. All penetrations entering or exiting a space with a clean agent fire suppression system shall be through conduit or a conduit sleeve.
  - b. All penetrations shall be sealed with a UL listed fire stop system.
  - c. Conduits and sleeves exiting the space shall be sealed externally at the penetration and internally at the conduit termination.
  - d. All innerducts and sub-ducts shall be sealed externally at the penetration and internally at the cable exit.
  - e. Conduit, conduit sleeve and innerduct seals shall form a cold smoke seal as well as a fire resistant seal.
  - f. Coordinate the exact requirements for sealing conduit and cable penetrations with the Contractor responsible for the clean agent fire suppression system.
10. Bond all metal raceways to ground at utility poles, hand holes, man holes and at building entrances and other locations as required by Code and Section 16170, Grounding and Bonding.

## 2.2 EXTERIOR PATHWAYS

### A. Installation shall be as specified as follows:

1. Conduit bodies shall not be installed in conduits to contain telecommunications cables (fiber, category rated, coax). Provide properly sized pull boxes at locations require the use of a conduit body for pulling cable. Pull boxes shall be sized to support cable minimum bend radius of the largest cable to be installed.
2. Conduits for telecommunications cables shall be installed so that not more than 2 quarter bends (180 degrees) between pull points.
3. Conduits for telecommunications utility service entrance conduits shall be turned up at utility pole locations in rigid steel conduit (RGS) to a minimum of three feet above finished grade.
4. Rod, swab and perform a mandrel test on all exterior conduits following backfill and concrete encasement to verify that the conduit has not been damaged during installation. Remove and replace any conduits exhibiting damage at no additional cost to the Owner or End Users.
5. Install temporary caps on all exterior conduits to prevent ingress of water and foreign materials after mandrel testing and before installation of innerducts and cables.
6. Provide a 1200 lb. test pull tape in each telecommunications conduit and innerduct.
  - a. Pull tapes shall not be installed with cables.

- b. Contractor shall remove pull tapes from conduits after cable installation, fish-tape or rod the conduit/duct and install a new pull tape after all cables are installed.
- 7. Seal all conduits and raceways penetrations with duct seal (outside conduits) and mechanical duct plugs (inside conduits).
  - a. Size duct plugs for proper seal around installed cables.
- 8. Provide firestop systems around all pathways through and floor wall penetrations in all fire rated structures.
- 9. Provide sealed fire stop systems at all pathways through wall and floor penetrations in the equipment room and all spaces equipped with a clean agent fire suppression system.
  - a. All penetrations entering or exiting a space with a clean agent fire suppression system shall be through conduit or a conduit sleeve.
  - b. All penetrations shall be sealed with a UL listed fire stop system.
  - c. Conduits and sleeves exiting the space shall be sealed externally at the penetration and internally at the conduit termination.
  - d. All innerducts and sub-ducts shall be sealed externally at the penetration and internally at the cable exit.
  - e. Conduit, conduit sleeve and innerduct seals shall form a cold smoke seal as well as a fire resistant seal.
  - f. Coordinate the exact requirements for sealing conduit and cable penetrations with the Contractor responsible for the clean agent fire suppression system.
- 10. Bond all metal raceways to ground at hand holes, man holes and at building entrances and other locations as required by Code and Section 16170, Grounding and Bonding.

## 2.3 INTERIOR PATHWAYS

- A. Installation shall be as specified as follows:
- B. Conduit bodies shall not be installed in conduits to contain telecommunications cables (fiber, category rated, coax). Provide properly sized pull boxes at locations require the use of a conduit body for pulling cable. Pull boxes shall be sized to support cable minimum bend radius of the largest cable to be installed.
- C. Conduits for interior telecommunications cables shall be installed so that not more than 3 quarter bends (270 degrees) between pull points, if the final bend is within 12" of the end of the conduit, if not the fill must be de-rated, per BICSI TDM.
- D. Rod, swab and perform a mandrel test on all interior conduits (2 inches and larger) installed in slab or below slab following concrete encasement to verify that the conduit has not been damaged during installation. Remove and replace any conduits exhibiting damage at no additional cost to the Owner or End Users.
- E. All penetrations through rated walls and all floors shall be sleeved with 4" conduit.
  - 1. Conduit sleeves shall extend beyond the surface of the finished wall a minimum of 12", to above an accessible ceiling.
  - 2. Extend conduits and conduit sleeves as required to terminate the end of the conduits above an area of accessible ceiling.
  - 3. Terminate all conduit sleeves with conduit connectors and plastic or phenolic bushings.

4. Install a UL listed or approved firestop system for each penetration in a fire or smoke rated structure.
- F. All penetrations through non-rated walls shall be sleeved and filled with acoustic batting to minimize sound transmission through the wall penetration. Provide conduit sleeves, sized as required (minimum 2"C) for non-rated wall penetrations. Cable tray penetrations through walls shall be framed with sheet metal studs and insulated as shown on the Drawings.
- G. Provide a 600 lb. test pull cord in each telecommunications conduit and innerduct.
  1. Pull tapes shall not be installed with cables.
  2. Contractor shall remove pull tapes from conduits after cable installation, fish-tape or rod the conduit/duct and install a new pull tape after all cables are installed.
- H. Provide through penetration firestop systems around all pathways through floor and wall penetrations in all fire rated structures.
- I. Provide membrane fire stop systems for all raceways and boxes installed through one side of a rated structure.
- J. Provide sealed fire stop systems at all pathways through wall and floor penetrations in the equipment room and all spaces equipped with a clean agent fire suppression system.
  1. All penetrations entering or exiting a space with a clean agent fire suppression system shall be through conduit or a conduit sleeve.
  2. All penetrations shall be sealed with a UL listed fire stop system.
  3. Conduits and sleeves exiting the space shall be sealed externally at the penetration and internally at the conduit termination.
  4. All innerducts and sub-ducts shall be sealed externally at the penetration and internally at the cable exit.
  5. Conduit, conduit sleeve and innerduct seals shall form a cold smoke seal as well as a fire resistant seal.
  6. Coordinate the exact requirements for sealing conduit and cable penetrations with the Contractor responsible for the clean agent fire suppression system.
- K. Bond all metal raceways to ground in the telecommunications rooms, equipment rooms and other locations as required by Code and Section 16170, Grounding and Bonding.

## 2.4 SEISMIC AND VIBRATION CONTROLS

- A. Installation shall be as specified in Section regarding Seismic Controls for Electrical Work.

## 2.5 IDENTIFICATION AND DOCUMENTATION

### A. Utility Documentation

1. The Contractor shall document the cable types, pair counts, strand counts and cable identification of all utility service entrance cables on the Record Drawings.
2. The Contractor shall identify the conduits used by the utility service providers and the remaining spare conduits on the Record Drawings.

### B. Grounding and Bonding Identification

1. Label each ground bus bar and all telecommunications bonding backbone wires.

- a. Provide a non-conductive engraved plastic laminate label plate in the upper left hand corner of the bus bar.
    - b. Label each ground wire with the location of origin and destination location in the same manner as backbone cables.
    - c. Provide a non-metallic tag shall be used at each connection of the telecommunications bonding backbone wires. The brass tag shall have the legend "Telecommunications Ground - Do Not Disconnect". The brass tag shall be tied to the ground wire within six inches of the termination with a brass wire or stainless steel strap.
  2. Label each bonding conductor in each telecommunications space and in the consolidation points with the location of origin (bus bar) and destination location (cabinet, rack, enclosure, etc.)
- C. Interior Identification
1. All cables, devices, jacks, faceplates, cabinets, termination hardware, cable tray, etc. shall be labeled as indicated herein, on the Drawings and as coordinated with the End Users.
  2. Labeling and identification shall include, but is not limited to the following:
    - a. Horizontal distribution cables
    - b. Backbone cables
    - c. Conduits
    - d. Cable trays and ladders
    - e. Cabinets and racks
    - f. Patch Panels
    - g. Fiber termination enclosures
    - h. Termination hardware
    - i. Wireless access point locations
    - j. Consolidation points
    - k. Consolidation point locations
    - l. Outlet plates
    - m. Jacks
    - n. Connectors
  3. Coordinate final labeling and identification system with End Users prior to start of rough-in.
    - a. Preliminary label schemes are shown on the Drawings.
    - b. Contractor shall use these preliminary label schemes to develop a detailed cable running list and a detailed device and equipment identification list.
    - c. Contractor shall coordinate the detailed lists with the End Users prior to cable rough-in.
  4. Apply all labels plumb and square to the cable, device and equipment.
  5. All flexible cable, faceplate and equipment labels shall be adhesive backed.
  6. Label each outlet conduit above accessible ceiling.

- a. Each outlet conduit shall be identified with the respective outlet number.
  - b. Outlet conduits shall be marked legibly with indelible marker or machine printed label approximately six inches from the end of the conduit.
  - c. Conduits shall be identified after painting is complete; or mask the identification location prior to painting and remove the masking after painting is complete.
7. Label each backbone conduit pathway with its location of origin and destination location.
  - a. Backbone conduits shall be marked legibly with indelible marker or machine printed label approximately six inches from the end of the conduit.
  - b. Conduits shall be identified after painting is complete; or mask the identification location prior to painting and remove the masking after painting is complete.
8. Label each cabinet and rack with a non-conductive engraved laminated plastic label plate.
  - a. The label plates shall be installed in the upper left hand corner on the face of the cabinets and racks.
9. Label each cable tray with cable tray warning labels at 10 foot intervals or as otherwise recommended by the manufacturer.
10. Label each patch panel with an adhesive backed label in the upper left hand corner of the face of each patch panel.
11. Label each fiber termination enclosure with an adhesive backed label on the upper left hand corner on the face of each fiber termination enclosure.
  - a. Label each connector group with the location of origin and destination location information associated with the respective fiber cable.
  - b. Label each fiber port with individual fiber strand numbers 1 through N (where N= strand count).
  - c. Label individual ports for horizontal distribution fibers with the outlet jack identification number.
12. Label termination hardware (e.g. 110 style termination blocks) shall be labeled using designation strips and designation strip holders as recommended by the hardware manufacturer.
  - a. Copper backbone termination hardware shall be labeled with the location of origin and destination locations associated with the respective copper backbone cable.
  - b. For backbone copper cables, label the first and last pair number on each termination row (e.g. 1 → 25).
  - c. For horizontal distribution copper cables at consolidation points, label each four pair group with its respective jack number.
13. Label wireless access point outlet locations on the ceiling grid below the wireless access point outlet in addition to the faceplate and jack labels.
  - a. Provide a non-conductive engraved laminated plastic label plate.
  - b. Affix the label to the ceiling grid with a releasable double sided tape to allow relocation of the label plate if required.
14. Label consolidation outlets and consolidation outlet locations.
  - a. Provide a non-conductive engraved laminated plastic label plate affixed to the lower left hand corner of the consolidation point enclosure.

- b. Provide a non-conductive engraved laminated plastic label plate affixed to the ceiling grid below the consolidation point location.
- 15. Label individual outlet plates with an adhesive backed label.
  - a. A single outlet plate label is sufficient for labeling two or more plates for floor boxes containing multiple outlet plates.
- 16. Label individual jacks and connectors with individual port numbers and cable category ratings (where applicable).
- 17. Unless noted otherwise, apply non-conductive laminated plastic engraved labels with transfer adhesive on smooth surfaces in environmentally conditioned spaces.
- 18. Apply non-conductive laminated plastic engraved labels with #4 sheet metal screws or #4 machine screws and nuts on textured surfaces and outside of environmentally conditioned spaces.

D. Exterior Identification

- 1. All cables, devices, jacks, faceplates, cabinets, termination hardware, cable tray, etc. shall be labeled as indicated herein, on the Drawings and as coordinated with the End Users.
- 2. Labeling and identification shall include, but is not limited to the following:
  - a. Horizontal distribution cables
  - b. Backbone cables
  - c. Conduits
  - d. Fiber termination enclosures
  - e. Media van parking area outlet enclosures
  - f. Outlet plates
  - g. Jacks
- 3. Connectors
  - a. Coordinate final labeling and identification system with End Users prior to start of rough-in.
  - b. Preliminary label schemes are shown on the Drawings.
  - c. Contractor shall use these preliminary label schemes to develop a detailed cable running list and a detailed device and equipment identification list. Refer to Appendix A of this Section for an example of the cable running list to be developed and completed by the Contractor.
  - d. Contractor shall coordinate the detailed lists with the End Users prior to cable rough-in.
- 4. Apply all labels plumb and square to the cable, device and equipment.
- 5. All flexible cable, faceplate and equipment labels shall be adhesive backed.
- 6. Label each backbone conduit pathway with its location of origin and destination location.
  - a. Provide an embossed or molded plastic label strip on each conduit at the utility service pole.
  - b. Provide an embossed or molded plastic label strip on each entrance conduit. Install the label with nylon cable ties or stainless steel straps. Label strips shall be installed vertically on the side of each conduit so the identification is visible.

- c. Provide an embossed or molded plastic label strip for each conduit in each handhole. Where the conduits protrude into the handhole, the label strips shall be applied directly to the conduit. Where the conduits do not extend into the handhole, affix the label to the handhole wall adjacent to the conduit.
  7. Label media van connection enclosures with a non-conductive engraved laminated plastic label plate affixed to the lower left hand corner of the enclosure.
    - a. Label fiber cables in the same manner as outlet plates
    - b. Label individual fiber strands in the same manner as individual jacks.
  8. Label individual coaxial connections in the same manner as individual jacks.
  9. Apply non-conductive laminated plastic engraved labels with #4 sheet metal screws or #4 machine screws and nuts.
- E. Test Documentation
1. Provide summary and detailed test reports of all testing performed.
  2. Provide test reports in electronic format and provide a software reader to display the summary and detailed test report.
  3. Provide a letter of certification from the Contractor verifying that all of the tests performed are in accordance with the requirements of this document, industry standards as specified, and that all installed cables and components meet or exceed the requirements of these documents.
- F. As-Built Record Documents
1. Operation and Maintenance Manuals (for active equipment and systems)
  2. Product information (Approved submittals)
  3. Record Drawings
  4. Cable Identification Records
  5. Test Records
  6. Seismic and Vibration Control
- G. Provide Record Drawings detailing the location and identification of all components installed as part of this Work. The Record Drawings shall include, but are not limited to showing the following:
1. Telecommunications Room locations and identification
  2. Telecommunications outlet locations and identification
  3. Telecommunications riser with identification of each backbone cable.
  4. Telecommunications cabinet and rack identification.
  5. Telecommunications grounding and bonding backbone and bus bar locations and identification.
  6. Telecommunications raceway locations and routing
    - a. Exterior conduits, location of origin, destination location and route.
    - b. Cable trays and ladders
    - c. Interior conduits, backbone conduit runs only.
    - d. Interior and exterior conduit identification.

7. A draft copy of the project Record Drawings shall be provided to the End Users' Information Technology Department a minimum of 30 days prior to the project acceptance or turn over for the End Users' beneficial use.
  - a. At a minimum, the draft copy of the Record Drawings shall show all outlets installed with cable/jack identification clearly marked.
  - b. The draft copy may be used by the Owner to begin patching, connection and testing of network equipment.
  - c. The Contractor shall notify the End Users of any changes in the labeling scheme and any requirements to test cables that are patched or connected after delivery of the draft Record Drawings.

H. Seismic and Vibration Controls Documentation

1. Document seismic and vibration controls and measures installed on the Record Drawings.
2. Show location and details for seismic and vibration controls and measures installed.

2.6 TESTING

A. Copper Cable Testing - All Copper Cables

1. Inspect all terminations to verify that all conductors are properly seated in the connection.
2. Inspect all cables for evidence of stretching, over bending or damage during installation.
3. Test all copper cables for the following:
  - a. DC loop resistance
  - b. Polarity between conductors
  - c. Shorts
  - d. Opens
  - e. Intermittent faults
4. Test all cables prior to patching and cross-connecting.
5. Test all voice circuits for the parameters above from end to end.
6. Document all tests as pass/fail.
7. Contractor shall repair or replace all cables not passing these tests at no additional cost to the End Users or Department.

B. Copper Cable Testing - Performance Testing

1. Test all Category Rated cables for the following:
  - a. Wire map
  - b. Length
  - c. Insertion loss
  - d. Near-end cross-talk (NEXT)
  - e. Power sum near-end cross-talk (PSNEXT)
  - f. Equal-level far-end cross-talk (ELFEXT)
  - g. Power sum equal-level far-end cross-talk (PSELFEXT)

- h. Return Loss
  - i. Propagation delay
  - j. Delay Skew
- 2. Test all cables prior to patching.
- 3. Performance test equipment shall meet or exceed the requirements of TIA/EIA-568 C.2.
- 4. Document all tests as pass/fail and include worst cast test measurements for each test parameter.
- 5. Contractor shall repair or replace all cables not passing these tests at no cost to the End Users or Department.

C. Fiber Cable Testing

- 1. Each fiber shall be tested for insertion loss (attenuation) and continuity with an optical loss test set comprised of an optical power meter and stabilized light source. Optical time domain reflectometer (OTDR) testing will not be accepted for insertion loss testing.
- 2. The maximum link loss for each cable segment shall be calculated and submitted for approval prior to the start of testing.
- 3. The maximum link loss shall be calculated for both primary wavelengths of each type of fiber.
  - a. Backbone single mode fibers shall be less than 1.5 dB attenuation at both wavelengths.
- 4. The maximum link loss shall be calculated using the connector and cabled fiber loss values from the TIA 568C.3 optical cable standards or the manufacturer's specified guaranteed maximum insertion loss values, whichever is more stringent.
- 5. Document the values used in the calculations.
- 6. Test results shall be evaluated based on the calculated maximum link loss for each cable segment.
- 7. Test each backbone fiber in both directions at both wavelengths
- 8. Test each horizontal distribution fiber in one direction at one wavelength.
- 9. Multimode fiber shall be tested in accordance with TIA 526-14A, Method B, one jumper reference, two jumper test.
  - a. Backbone multimode fibers shall be tested at 850 and 1300 nm wavelengths.
  - b. Horizontal distribution multimode fibers shall be tested at 850 nm wavelength.
- 10. Single mode fibers shall be tested in accordance with TIA 526-7, Method A, one jumper reference, two jumper test.
  - a. Backbone single mode fibers shall be tested at 1310 and 1550 wavelengths.
  - b. Horizontal distribution single mode fibers shall be tested at 1310 nm wavelength.
- 11. Document all tests as the actual dB insertion loss of each fiber, at both wavelengths, in both directions.
- 12. Contractor shall repair or replace all cables not passing these tests at no additional cost to the End Users or Department.

D. Test Equipment Requirements

1. All test equipment shall be under current calibration
  2. Test equipment calibration shall be traceable to National Institute of Standards and Technology (NIST) or a Nationally Recognized Testing Laboratory (NRTL).
  3. Submit calibration certificates for all test equipment as part of the project submittals.
  4. Include calibration certificates for all test equipment as part of the test As-Built Record Documents.
- E. As-Built Record Documents shall be provided in hard copy and electronic formats.
1. Hard copy documents may be requested on 8-1/2" x 11" paper, 11" x 17" paper, full-size plotted drawings and half size plotted drawings.
  2. Hard copy documents may be requested in three ring binders or bound format.
  3. All binders and bound copies shall include the official project name, Department's project number, Contractor name and Contractor's contact information on the project cover.
  4. All binders and bound copies shall include an index, tabbed sections and volume numbers where applicable.
  5. All hard copy drawings shall be bound and stapled.
  6. Electronic files shall be provided in the original native file format of the program used to create the files.
  7. Electronic files shall not be password protected or otherwise protected to prevent the Department and End Users full access and use of the information.
  8. Electronic document files may be requested in Microsoft Word, Microsoft Excel, Microsoft Visio, AutoCAD or other software formats.
  9. The Contractor shall coordinate the requirements for hard and electronic format deliverables with the Department and the End Users prior to delivery of the As-Built Record Documents.
  10. In addition to the As-Built Record Documents to be delivered to the Department as required by the Division 1 Specifications, the Contractor shall provide two hard copy sets of the Drawings, an electronic copy of the drawings and an electronic copy of the cable system test reports to the End Users's Information Technology (IT) Department for their use. These documents shall be delivered directly to the Owner's IT Department point of contact. Coordinate this requirement with the Architect prior to delivery of the As-Built Record Documents.

END OF SECTION

## APPENDIX A

### Sample Cable Identification Record - Horizontal Distribution

Telecom Room ID	Outlet Box #	Cable/Jack #	Rack #	Patch Panel #	Port #	Cable Type	Notes
A	A-001	AD220401	D22	04	01	Cat6A	
A	A-001	AD220801	D22	08	01	Cat6	
A	A-001	AD220802	D22	08	02	Cat6	
A	A-001	AD220803	D22	08	03	Cat6	
A	A-002	AD220402	D22	04	02	Cat6A	
A	A-002	AD220804	D22	08	04	Cat6	
A	A-002	AD220805	D22	08	05	Cat6	
A	A-002	AD220806	D22	08	06	Cat6	
A	A-003	AD220403	D22	04	03	Cat6A	
A	A-003	AD220807	D22	08	07	Cat6	
A	A-003	AD220808	D22	08	08	Cat6	
A	A-003	AD220809	D22	08	09	Cat6	
A	A-004	AD220404	D22	04	04	Cat6A	
A	A-004	AD220810	D22	08	10	Cat6	
A	A-004	AD220811	D22	08	11	Cat6	
A	A-004	AD220812	D22	08	12	Cat6	
A	A-005	AD220405	D22	04	05	Cat6A	
A	A-005	AD220813	D22	08	13	Cat6	
A	A-005	AD220814	D22	08	14	Cat6	
A	A-005	AD220815	D22	08	15	Cat6	
A	A-006	AD220406	D22	04	06	Cat6A	
A	A-006	AD220816	D22	08	16	Cat6	
A	A-007						Spare
A	A-008	AD220407	D22	04	07	Cat6A	
A	A-008	AD220817	D22	08	17	Cat6	
A	A-009						Spare
A	A-010	AD220408	D22	04	08	Cat6A	
A	A-010	AD220818	D22	08	18	Cat6	
A	A-011	AD220409	D22	04	09	Cat6A	
A	A-011	AD220819	D22	08	19	Cat6	
A	A-012	AD220410	D22	04	10	Cat6A	
A	A-012	AD220820	D22	08	20	Cat6	
A	A-013	AD220411	D22	04	11	Cat6A	
A	A-013	AD220821	D22	08	21	Cat6	

**Sample  
Cable Identification Record – Backbone Distribution**

Telecom Room ID Origin	Rack #	FTE/Patch Panel #	Port #s	Telecom Room ID Destination	Rack #	FTE/Patch Panel #	Port #s	Cable Type
A	D24	01	01-12	B	A01	01	01-12	FM
A	D24	01	13-24	B	A01	01	13-24	SM
A	D25	06	01-24	B	A01	02	01-24	CU
A	B18	N/A	N/A	B	A02	N/A	N/A	CO
A	D24	01	25-36	C	A01	01	01-12	FM
A	D24	01	37-48	C	A01	01	13-24	SM
A	D25	06	25-48	C	A01	02	01-24	CU
A	B18	N/A	N/A	C	A02	N/A	N/A	CO
A	D24	01	49-60	D	A01	01	01-12	FM
A	D24	01	61-72	D	A01	01	13-24	SM
A	D24	07	01-24	D	A01	02	01-24	CU
A	B18	N/A	N/A	D	A02	N/A	N/A	CO
A	D24	02	01-12	E	A01	01	01-12	FM
A	D24	02	13-18	E	A01	01	13-24	SM
A	D25	07	25-48	E	A01	02	01-24	CU
A	B18	N/A	N/A	E	A02	N/A	N/A	CO

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## SECTION 270526 GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

### 1.1 WORK INCLUDED

- A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

### 1.2 SCOPE OF WORK

- A. This section includes the minimum requirements for the equipment and cable installations in communications equipment rooms; e.g., main distribution frame (MDF), intermediate distribution frame (IDF), radio equipment rooms, audio/media equipment and related areas, emergency operations (EOC) rooms, and any other areas deemed by the authority having jurisdiction (AHJ).
- B. Included in this section are the minimum composition requirements and installation methods for the following:
  - 1. Interior grounding systems which include the following, but not limited to items:
    - a) Busbars
    - b) Grounding/bonding conductors
    - c) Bonding accessories
    - d) Raised floor bonding grid

### 1.3 QUALITY ASSURANCE

- A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufactures listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.
- B. Strictly adhere to all project drawing and specifications, Motorola R56®, Standards and Guidelines for Communication Sites, Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling, the more stringent shall apply.
- C. Material and work specified herein shall comply with the applicable requirements of the following standards and the Authority Having Jurisdiction (AHJ). The more stringent shall apply.
  - 1. Motorola R56® (R56) - *Standards and Guidelines for Communication Sites*
  - 2. ANSI/TIA/EIA – 568 *Commercial Building Telecommunications Cabling Standard* – latest edition
  - 3. TIA – 569 *Commercial Building Standard for Telecommunications Pathways and Spaces*– latest edition

4. *ANSI/TIA/EIA – 606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings*– latest edition
5. *ANSI-J-STD – 607 Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications*– latest edition
6. *NFPA 70 – National Electric Code*
7. *BICSI – Telecommunications Distribution Methods Manual, 14<sup>th</sup> Edition,*

#### 1.4 SUBMITTALS

- A. Provide product data for the following:
  - a) Provide with bid submittal the intent for compliance for grounding and bonding per these specifications.
  - b) Provide manufacturer's cut sheets, specifications, and installation instructions for all products, before installation.

#### 2.1 WALL/FLOOR-MOUNT BUSBARS

- A. Primary Bonding Bar (PBB)
  1. Primary bonding bar (PBB) shall be constructed of .25" (6.4 mm) thick solid copper bar. The bar may be tin-plated and is required in damp/wet or when mounted to galvanized surfaces.
  2. The busbar shall be 4"H x 20"L (100 mm x 510 mm) and shall have attachment points for two-hole grounding lugs, with 20% future growth.
  3. The hole pattern for attaching grounding lugs shall meet the requirements of R56 and should accept lugs with ¾ (19 mm) or 1" (24.5 mm) hole centers.
  4. The busbar shall include wall-mount stand-off brackets, assembly screws and 2kV minimum voltage rating insulators.
  5. The busbar shall be UL Listed as grounding and bonding equipment.
- B. Secondary Bus Bar (SBB)
  1. Secondary bonding bar (SBB) shall be constructed of .25" (6.4 mm) thick solid copper bar. The bar may be tin-plated and is required in damp/wet or when mounted to galvanized surfaces.
  2. The busbar shall be, minimally, 4"H x 12"L (100 mm x 300 mm), and shall be properly sized to accommodate two-hole grounding lugs, with 20% future growth.
  3. The hole pattern for attaching grounding lugs shall meet the requirements of R56 and should accept lugs with ¾ (19 mm) or 1" (24.5 mm) hole centers.
  4. The busbar shall include wall-mount stand-off brackets, assembly screws and 2kV minimum voltage rating insulators.
  5. The busbar shall be UL Listed as grounding and bonding equipment.
- C. Operator Station Secondary Bonding Bar (OSBB)

1. Operator Station Secondary Bonding Bar (OSBB) shall be constructed of .25" (6.4 mm) thick solid copper bar. The bar may be tin-plated and is required in damp/wet or when mounted to galvanized surfaces.
2. The busbar shall be 2"H x 12"L (50 mm x 300 mm) and shall be properly sized to accommodate two-hole grounding lugs, with 20% future growth.
3. The hole pattern for attaching grounding lugs shall meet the requirements of R56 and should accept lugs with  $\frac{3}{4}$ " (19 mm) or 1" (24.5 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and 2kV minimum voltage rating insulators.
5. The busbar shall be UL Listed as grounding and bonding equipment.

## 2.2 RACK BONDING BAR (RBB)

### A. Horizontal Rack Bonding Bar (RBB)

1. Horizontal rack-mount busbar shall be constructed of minimally 3/16" (4.76 mm) thick by 1/2"H (12.7 mm) alloy copper or tin-plated copper bar. The bar may be tin-plated and is required in damp/wet or when mounted to galvanized surfaces.
2. Bar shall be 19" EIA or 23" rack mounting width as best fit for mounting on relay racks or in cabinets.
3. Bar shall have 10-32 tapped (1/4" preferred), minimally, ground mounting holes on 1" (25.4 mm) holes spaced to maximize equipment bonding conductor quantities.
4. Stainless-steel (300-series) studs or holes sized to accommodate 5/16-inch SS hardware, on  $\frac{3}{4}$ " or 1-inch centers shall be provided on each end for attachment of a double-hole bonding lug.
5. Bar shall be UL Listed as grounding and bonding equipment.

### B. Vertical Rack Bonding Bar (RBB)

1. Vertical rack-mount busbar shall be constructed of minimally 3/16" (4.76 mm) thick by 1/2"H (12.7 mm) alloy copper or tin-plated copper bar. The bar may be tin-plated and is required in damp/wet or when mounted to galvanized surfaces.
2. Bar shall be 72"H (1830 mm) or 36"H (910 mm) as required for best fit for coverage of the rack height.
3. 72"H (1830 mm) bar shall have 13 threaded 1/4-20 attachment points for two-hole lugs with 5/8" (15.8 mm) hole centers and two pairs of threaded studs (one at top, one at bottom) for two-hole lugs with 1" (25.4 mm) hole centers.
4. Bar shall have 10-32 tapped (1/4" preferred), minimally, ground mounting holes on 1" (25.4 mm) holes spaced to maximize equipment bonding conductor quantities.
5. Stainless-steel (300-series) studs or holes sized to accommodate 5/16-inch SS hardware, on  $\frac{3}{4}$ " or 1-inch centers shall be provided on each end for attachment of a double-hole bonding lug.
6. Bar shall be UL Listed as grounding and bonding equipment.

## 2.3 BONDING ACCESSORIES

### A. Compression Lugs

1. Compression lugs shall be manufactured from tinned-plated copper.
2. Compression lugs shall have two holes spaced properly to secure to the bus bar.
3. Compression lugs shall be sized to fit its specific size conductor.
4. Compression lugs shall be UL Listed as wire connectors.
5. Two-hole compression lugs shall be installed on the PBB and SBB for bonding all grounding conductors.
6. One-hole compression lugs are allowed to be used on rack/cabinet-mounted equipment bonding conductors attached to equipment and the RBB.
7. Interior lug connections shall be irreversibly crimp connectors, crimped to 2-ton force, minimally.

B. Antioxidant Joint Compound

1. Oxide inhibiting joint compound for copper-to-copper and tin-plated copper to copper, shall be a copper-based ointment.
2. Oxide inhibiting joint compound for copper or tin-copper to other metallic surfaces or other metallic bonding shall be a zinc-based ointment.
3. All mechanical connections shall have an antioxidant joint compound applied.

C. C-Type, Compression Taps

1. Compression taps shall be manufactured from copper alloy.
2. Compression taps shall be C-shaped connectors that wrap around two conductors forming an irreversible splice around the conductors; installation requires a hydraulic crimping tool
3. Compression taps shall be sized to fit specific size conductors.
4. Compression taps shall be UL Listed.
5. Compression taps shall be insulated to inhibit incidental contact with other metallic media.
6. Interior lug connections shall be irreversibly crimp connectors, crimped to 2-ton force, minimally.
7. Exterior lug connections shall be exothermically welded or irreversibly crimp connectors rated and installed for 12-ton force, minimally.

D. Pedestal Clamp with Grounding Connector

1. Pedestal clamp shall be made from electroplated tinned copper or bronze. Installation hardware will be 300-series stainless steel.
2. Pedestal clamps shall be sized to fit a specific size conductor.
3. Pedestal clamp installation hardware shall be sized to attach to round and/or square raised access floor pedestals that are 1-1/8" to 1-3/4" in diameter, as stated below.
4. Pedestal clamp shall provide straight (in-line) or cross (intersection) support for up to two conductors.
5. Pedestal clamp shall be UL Listed as grounding and bonding equipment.

E. Pipe Clamp with Grounding Connector

1. Pipe clamp shall be made from electroplated tinned bronze. Installation hardware will be stainless steel.
2. Pipe clamp shall be sized to fit up to two conductors ranging in size from #6 to 250 MCM; conductors must be the same size.

3. Pipe clamp installation hardware shall be sized to attach to pipes, sizes 1" to 6" (.75" to 6.63" in diameter), as stated below.
4. Pipe clamp shall be UL Listed as grounding and bonding equipment.

#### 2.4 BONDING GRID

1. The bonding grid shall be prefabricated.
2. The grid shall be made of 26 gauge (0.4 mm) by 2" (50 mm) wide copper strap.
3. The grid shall cross at 90-degree angles and exothermically welded together at 2' intervals, thus making a 2' by 2' grid pattern.

#### 2.5 GROUNDING AND BONDING CONDUCTORS

1. Shall be properly sized according to job specifications and drawings, Motorola R56 and TIA-607, the more stringent shall apply.
2. Minimally one bonding backbone conductor shall be installed to provide connection of the PBB to all other area SBBs. The size shall be maintained throughout the run.
3. The PBB shall bond to the electrical service common electrode bus via the same size conductor as the bonding backbone conductor.
4. All bus bars shall bond to the grounding system via conductors sized appropriately by their total length. Reference Motorola R56 table 5-3.
5. No. 2 AWG is the minimal sized conductor to be used for bus bar to system connections and for bonding multiple items (reference R56 for exceptions).

### 3.1 INSTALLATION

#### A. Wall/Floor-Mount Busbars

1. Attach busbars to the substrate with appropriate hardware according to the manufacturer's installation instructions.
2. Conductor connections to the PBB or SBB shall be made with two-hole bolt-on compression lugs sized to fit the busbar and the conductors.
3. Each lug shall be attached with 300-series stainless steel hardware after preparing the bond according to manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
4. The wall/floor-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.

#### B. Rack-Mount Busbars and Ground Bars

1. When a rack or cabinet supports active equipment or any type of shielded cable or cable termination device requiring a ground connection, add a rack-mount horizontal or vertical busbar to the rack or cabinet. The rack-mount busbar provides multiple bonding points on the rack for rack and rack-mount equipment.
2. Attach rack-mount busbars to racks or cabinets according to the manufacturer's installation instructions.
3. Bond the rack-mount busbar to the room's PBB, main SSB, or bonding grid with appropriately sized hardware and conductor.

#### C. Operator Station Secondary Bonding Bar

1. An operator station secondary bonding bar (OSBB) shall be installed within each operator's furniture, in a location as determined by the owner and design team.
2. The OSBB shall bond to the area's PBB, main SBB, or bonding grid via a No. 2 AWG conductor, minimally.
3. All metallic media at the operator's station shall be properly bonded to the OSBB using methods described in this section. Items that shall bond to the OSBB, but not limited to are:
  - a) AC power
  - b) Cable shields
  - c) Power distribution units (PDUs)
  - d) Metallic furniture parts
  - e) Surge protection devices (SPDs)
  - f) Additional floor pedestal located under the operator's seating area

D. Bonding Grid

1. The grid shall bond to the areas PBB or main SBB with two conductors sized per the backbone bonding conductor. The conductors shall bond on opposing extremes of the bus bar and radiate away from another. Attach the other end of the conductors to the grid via exothermic weld.
2. The grid shall lay flat on the floor with the floor pedestals centered within the open area of the 2'x2' grid pattern.
3. The operator's station SBB and equipment area racks shall bond to the grid via minimally a No. 2 AWG conductor.

E. Pedestal Clamp

1. At minimum, bond every fourth raised access floor pedestal, around the perimeter and within the field, with a minimum #6 AWG conductor to the bonding grid, via exothermic weld, and to the pedestal using a pedestal clamp sized to fit the pedestal and the conductor and installed according to the manufacturer's recommendations.
2. Bond each rack and/or cabinet to the bonding grid via minimally a No. 2 conductor exothermically welded to the grid. Attach the conductor to the PBB or SBB via two-hole lug.
3. Remove paint between the pedestal and pedestal clamp, clean surface and use antioxidant between the pedestal and the clamp to help prevent corrosion at the bond.
4. Remove insulation from conductors where wires attach to the pedestal clamp.
5. Bare conductors may be used in plenum areas but shall be installed to inhibit incidental contact with other metallic media.

F. Pipe Clamp

1. Bond metal pipes located inside the communication/equipment rooms with a minimum #6 AWG conductor to the PBB, SBB, or bonding grid using a pipe clamp sized to fit the pipe and the conductor and installed according to the manufacturer's recommendations.
2. Remove paint between the pipe and pipe clamp, clean surface and use antioxidant between the pipe and the clamp to help prevent corrosion at the bond.
3. Remove insulation from conductors where wires attach to the pipe clamp.

G. Equipment Ground Jumper Kit

1. Bond equipment to a rack-mount busbar using ground jumper according to Motorola R56 or the manufacturer's recommendations. The more stringent shall apply.
2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack-mount bus bar to help prevent corrosion at the bond.
3. The ground jumper shall be attached to the bus bar by using 300-series stainless-steel hardware.

END OF DOCUMENT

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SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

## 1.1 STIPULATIONS

- A. The specifications sections "General Conditions of Contract," "Special Conditions" and "Division 1 – General Requirements" form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Cable Tray (wire rod)
  - 2. Fire Stops
  - 3. J-Hooks (Not for use for communications and signaling wiring in Communications Center, per NFPA 1221, Section 5.5.)

## 1.3 RELATED SECTIONS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section. Refer to the following sections:
  - 1. Division 01 Section "Construction Waste Management"
  - 2. Section 260536 "Cable Trays for Electrical Systems", for cable trays and accessories

## 1.4 RELATED REQUIREMENTS

- A. Systems, design, equipment, components, cabling materials, installation, labeling and testing shall comply with these specifications and associated reference documents, including but not limited to the following:
  - 1. Motorola R56® – Standards and Guidelines for Communications Sites
  - 2. Harris Site Grounding and Lighting Protection Guidelines
  - 3. National Fire Protection Association (NFPA) 70 – National Electrical Code (NEC)
  - 4. American National Standards Institute/Telecommunications Industry Association (ANSI/TIA)-568-E – Commercial Building Cabling Standards
  - 5. ANSI/TIA-569-E – Commercial Building Standard for Telecommunications Pathways and Spaces
  - 6. ANSI/TIA-606-C – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
  - 7. ANSI/TIA-607-D – Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises
  - 8. ANSI/TIA-942-B – Telecommunications Infrastructure Standard for Data Centers
  - 9. Building Industries Consulting Services, International (BICSI) Telecommunications Distribution Methods Manual (TDMM), latest edition
  - 10. ANSI/BICSI-002-2019 – Data Center Design and Implementation Best Practices
  - 11. All other applicable electrical and building codes.

## 1.5 SUBMITTALS

- A. Shop drawings shall be submitted and organized by specification section.
- B. Shop Drawings:
  - 1. Complete bill of materials
  - 2. Product cut sheets indicating materials, finish, dimensions, and all accessories.

## 2.1 CABLE TRAY (WIRE ROD)

- A. Provide cable trays in quantities, locations, and layouts per the plan drawings. Provide all necessary accessories and mounting equipment for a complete and first-class installation.
- B. Description:
  - 1. Welded wire mesh cable management system
- C. Material:
  - 1. Carbon Steel
- D. Finish:
  - 1. Electro-plated Zinc Galvanizing: ASTM B 633
- E. Construction:
  - 1. Cable trays shall be constructed with high strength welded steel wire mesh. Wire rod tray is to have a continuous safety edge wire lip. Wire rod tray sections shall be mechanically connected with ends finished to protect installers and cables.
- F. Inside Width:
  - 1. Products should be available in 6 inch, 8 inch, 12 inch and 22 inch widths.
    - a. Provide cable tray in 18 inch widths (per Motorola R56) unless otherwise noted on the project drawings.
- G. Inside Depth:
  - 1. Products should be available in 1- ½ inch, 2 inch and 4 inch depths.
    - b. Provide cable tray in 4 inch depths unless otherwise noted on the project drawings.

- H. Support:
  - 1. Provide all necessary accessories for cantilever bracket, trapeze support, or single rod suspension support.
- I. Tray sections shall be supplied in nominal 10 foot lengths.
- J. Mesh Spacing:
  - 1. 4 inches x 2 inches.
- K. All tray section splices shall use connectors designed for that purpose from the same manufacturer. Connectors must protect cables from sharp edges to prevent damage.
- L. Provide manufacturer's standard clamps, hangers, brackets, splice plates, blind ends, barrier strips, connectors, grounding straps, and all other apparatus is required.
- M. Hardware used to connect tray sections must be by same manufacturer and insure grounding continuity.
- N. When tray makes up to a 90-degree change in direction none of the inside corners shall be at 90 degrees. The contractor shall provide radial and or angled inserts to protect the min. bend radius of the cables.
- O. Grounding and Bonding
  - 1. All cable trays shall be electrically continuous and bonded to the telecommunications grounding system.
  - 2. Adjacent trays shall be bonded using UL listed splices or bonding jumpers.
  - 3. An electrical grounding conductor shall be used at all discontinuous joints (i.e. conduit sleeves or EZ paths). Size conductor per NEC and Motorola R56, the more stringent shall apply.
- P. Manufacturers:
  - 1. Cooper B-Line - FlexTray
  - 2. Legrand - Cablofil
  - 3. Or approved equal

## 2.2 UL LISTED FIRESTOPS

- A. Provide firestops in types, quantities, and locations per the Contract drawings.
- B. Provide re-enterable, non-hardening, intumescent putty, rated for floor or wall rating, UL approved assembly, with approved packing material for firestopping all inside building cable penetrations.
- C. See drawings for cable tray through-wall firestop assembly.

D. Manufacturers:

1. STI - EZ-Path
2. Nelson Equal
3. 3M Equal

## 2.3 J-HOOKS

- A. J-Hooks shall be used to support all data/voice/video/CATV/fiber cable not in conduit, wire rod tray, cable runway, or other approved pathway. J-hooks shall be sized appropriately for supporting cables. J-hooks shall be suspended using all thread. Acoustic ceiling support wires shall not be used for J-hook suspension; all J-hooks must be rigidly supported with all thread and/or slick-rod to meet NEC 300-22 requirements (note that separate support wires, that only support the J-Hook and are connected at least two locations, above and to the t-bar ceiling or above twice are acceptable support means to meet NEC 300-22 requirements). All J-hooks minimum size of 2" unless larger sizes are needed; provide all accessories and appurtenances to completely fasten support, and install the J-hooks, whether or not shown on the drawings or called out herein.
- B. Provide all necessary appurtenances for complete installation.
- C. Manufacturers:
1. Erico Caddy-Cat32
  2. Or Equal

## 3.1 INSTALLATION

- A. Install metallic cable runway in accordance with NEMA VE-2 Application Information Section.
- B. Wire-rod type cable trays to be installed and supported using manufacturer's suggested loads and support spacing. Center hung cable trays are not acceptable.
- C. Install products in accordance with the Manufacturer's instructions.
- D. All innerduct and conduit traversing through a wall or floor shall be firestopped on both sides using intumescent putty.
- E. Provide supports at each connection point, at the end of each run, and at other points to maintain a maximum spacing between supports of 5 feet.
- F. Install cable runway and cable tray in such a manner that joints are not made at support brackets.

- G. Install horizontal section support brackets at a maximum of 2.5 feet from any junction or splice in the cable runway.
- H. Install support brackets for each cable runway and cable tray fitting, junction, or elbow.
- I. Provide ceiling trapeze or wall mount for all horizontal cable tray as required.
- J. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.
- K. Provide expansion joints in accordance with NEMA VE-2 for 25 degrees Fahrenheit maximum temperature variation.
- L. Install without exposed raw edges.
- M. Provide firestopping to sustain ratings when passing cable tray through fire-rated elements
- N. Bond cable tray/runway to provide grounding continuity with manufacture's grounding straps over the entire length. Provide mechanical connectors for tray/runway connection to the nearest Telecommunications busbar, Provide bonding jumper at each expansion joint and adjustable connection. Bonding of the cable tray sections and to the interior grounding system shall be per Motorola R56.
- O. Cable tray and/or cable runway without separation shall only support data and voice cabling. Install other low voltage cabling in separate raceway(s) or provide dividers in the cable tray/runway.
- P. Provide separate raceways for different cable systems as indicated on the drawings. Separate low voltage systems may require separate raceway systems.
- Q. Power cable shall not be installed in the same cable tray as low voltage signal cables.

### 3.2 SLEEVES

- A. The Contractor shall provide sleeves at all wall and floor to protect cabling and/or raceways installed as part of the telecommunications system. Each sleeve shall extend through the respective wall, floor or partition and shall be furnished with a connector and protective bushing.
- B. Sleeves through floor and wall penetrations shall extend a minimum of 3 inches above the finished floor or as indicated on drawings.
- C. Sleeves through fire rated structures shall have an appropriate fire stop system installed as indicated in - Chases and Openings.
  - 1. Conduits, innerducts or other raceways that are not part of a fully enclosed raceway system shall be considered sleeves for this requirement.

- D. Where conduits pass through waterproofed floors or walls, design of sleeves shall be such that waterproofing can be flashed into and around the sleeves.
- E. Space between floor sleeves and passing conduit shall be caulked with graphite packing and waterproof caulking compound as required for a waterproof installation.
- F. Sleeves through exterior walls below grade shall have the spaces between conduit and sleeve caulked watertight.
- G. Sleeves in bearing and masonry walls, floors, and partitions shall be of standard weight steel pipe finished with smooth edges. For other masonry partitions, through suspended ceilings and for concealed vertical piping, sleeves shall be No. 22 U.S.G. galvanized iron.
- H. All sleeves through exterior walls shall be:
  - 1. Properly installed at a slope sufficient to limit water ingress
  - 2. Securely cemented in place.
- I. All spaces between the sleeve and cable(s), innerduct(s) or other items entering the building shall be packed and caulked with a re-enterable material to prevent water from entering the building.

### 3.3 CHASES AND OPENINGS

- A. All openings or chases required for the installation of the telecommunications work in the building shall be coordinated with and provided by the General Electrical Telecommunications Contractor.
- B. The Contractor shall seal all openings made in fire rated floors, ceilings or partitions after the work has been installed. The material used for sealing the openings shall have a fire rating equal to or greater than the rating of the floor, ceiling or partition material. All fire stop material installed shall be U.L. classified. The fire stop materials shall be installed as part of a U.L. listed system approved for the type of structure, penetration and penetrating item(s).
- C. This Contractor shall patch and repair any openings, penetrations and/or damage caused by his work, to the satisfaction of the Owner. The patch and/or repair shall be restored in like-kind of the structure and finish surrounding the penetrated or damaged area to a scratch coat to be finished by others.

END OF SECTION

## SECTION 270543 - UNDERGROUND PATHWAYS AND STRUCTURES FOR COMMUNICATION 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.
- B. Specifically reference the following specifications:
  - 1. 260500 Common Work Results for Electrical
  - 2. 260526 Grounding and Bonding for Electrical Systems
  - 3. 270500 Common Work Results – Communications
  - 4. 270528 Pathways for Communications Systems
  - 5. 271000 Structured Cable System
  - 6. 271116 Equipment Rooms and Fittings

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Metal conduit and fittings, including GRC and PVC-coated GRC.
  - 2. Rigid nonmetallic duct, including fiberglass (RTRC).
  - 3. Duct accessories, including rigid innerduct and fabric innerduct.
  - 4. Precast concrete handholes.
  - 5. Polymer concrete handholes and boxes with polymer concrete cover.
  - 6. Fiberglass handholes and boxes with polymer concrete cover.
  - 7. Fiberglass handholes and boxes.
  - 8. High density plastic boxes.
  - 9. Precast manholes.
  - 10. Cast-in-place manholes.
  - 11. 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 conduit.
- E. IMC: Intermediate metal conduit.
- F. RNC: Rigid nonmetallic conduit.
- G. RTRC: Reinforced thermosetting resin conduit.
- H. SMC: Sheet molding compound.
- I. 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 and conduits and their accessories, including elbows, end bells, bends, fittings, duct spacers and solvent cement.
  - 3. Include accessories for manholes, handholes, boxes and other utility structures.
  - 4. Include underground-line warning tape.
- B. Shop Drawings:
  - 1. Precast or Factory-Fabricated Underground Utility Structures:
    - a. Include plans, elevations, sections, attachment details, and accessories.
    - b. Include duct entry provisions, including location and duct size.
    - c. Include reinforcement details.
    - d. Include frame and cover design and manhole chimneys.
    - e. Include ladder or step details, as necessary per project documentation, codes, manufacturer, and provider specifications, and other.
    - 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 location and duct size.
    - 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. Duct and Duct-Bank Coordination Drawings: 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.
- C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- D. Source quality-control reports.
- E. Field quality-control reports.

## 1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified in accordance with ASTM E329 for testing indicated.

## 1.7 FIELD CONDITIONS

- A. Interruption of Existing Communications Service: Do not interrupt communications service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary communications service in accordance with requirements indicated:
  - 1. Notify the proper authority, i.e., Architect, Construction Manager, and/or Owner no fewer than **five** days in advance of proposed interruption of communications service.
  - 2. Do not proceed with interruption of communications service without the property authority's written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.
- C. 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 METAL CONDUITS AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. PVC-Coated Steel Conduit: PVC-coated GRC.
  - 1. Comply with NEMA RN 1.
  - 2. Coating Thickness: 0.040 inch (1 mm), minimum.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
4. Calconduit.
5. Electri-Flex Company.
6. FSR Inc.
7. Korkap.
8. NEC, Inc.
9. Opti-Com Manufacturing Network, Inc (OMNI).
10. O-Z/Gedney; a brand of Emerson Industrial Automation.
11. Perma-Cote.
12. Picoma Industries, Inc.
13. Plasti-Bond.
14. Republic Conduit.
15. Southwire Company.
16. Thomas & Betts Corporation; A Member of the ABB Group.
17. Topaz Electric; a division of Topaz Lighting Corp.
18. Western Tube and Conduit Corporation.
19. Wheatland Tube Company.

D. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-C and TIA-758-C.

2.2 RIGID NONMETALLIC DUCTS, PVC

- A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC; as necessary per project documentation, codes, manufacturer, and provider specifications, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Underground Plastic Utilities Duct: Type DB-60-PVC and Type DB-120-PVC RNC, complying with NEMA TC 6 & 8 and with ASTM F512 for direct burial, with matching fittings complying with

NEMA TC 9 by same manufacturer as duct; as necessary per project documentation, codes, manufacturer, and provider specifications.

- C. Underground Plastic Utilities Duct: Type EB-20 PVC RNC, complying with NEMA TC 6 & 8, ASTM F512, and UL 651, with matching fittings complying with NEMA TC 9 by same manufacturer as duct.
- D. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. ARNCO Corp.
  - 2. Beck Manufacturing.
  - 3. CANTEX INC.
  - 4. CertainTeed Corporation.
  - 5. Condux International, Inc.
  - 6. Crown Line Plastics.
  - 7. ElecSys, Inc.
  - 8. Electri-Flex Company.
  - 9. Endot Industries Inc.
  - 10. IPEX USA LLC.
  - 11. Lamson & Sessions.
  - 12. Manhattan/CDT.
  - 13. National Pipe & Plastics.
  - 14. Opti-Com Manufacturing Network, Inc (OMNI).
  - 15. Spiraduct/AFC Cable Systems, Inc.
- E. General Requirements for Nonmetallic Ducts and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
  - 2. Comply with TIA-569-C and TIA-758-C.
- F. Solvents and Adhesives: As recommended by duct manufacturer.

## 2.3 RIGID NONMETALLIC DUCT AND FITTINGS, RTRC FIBERGLASS

- A. RTRC Fiberglass Elbows:
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Champion Fiberglass, Inc.; RTRC fiberglass conduit or comparable product.
  - 2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 3. Fiberglass:
    - a. Comply with NEMA TC 14.
    - b. Comply with UL 2515 for aboveground raceways.
    - c. Comply with UL 2420 for belowground raceways.
  - 4. Conduit Material: RTRC fiberglass, manufactured using the single-circuit filament winding process. Multi-circuit windings are not allowed.
  - 5. Winding Angle: As close as possible to 54.75 degrees.

- a. Winding mandrels shall be straight and true so as to produce a non-tapered conduit. Tapering is allowed at the belled end.
  6. Resin System: Epoxy based, with no fillers, using an anhydride curing agent.
    - a. Fiberglass shall consist of continuous E-glass Grade "A" roving.
    - b. All additives for increasing flame spread and lowering smoke density shall be halogen free, i.e., not contain chlorine or bromine.
  7. Carbon black shall be used as UV inhibitor to protect the conduit and fittings during storage and exposure to the outdoors.
    - a. Conduit and elbows shall be black or gray in color, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
  8. Curing shall be done using an oven and shall take place in two steps.
    - a. First curing zone shall bring the conduit slowly to the gel temperature. The second zone shall post-cure the conduit at no less than 350 deg F (177 deg C).
    - b. Pipe must be properly cured so that when measuring the glass transition temperature with a differential calorimeter the difference between the first measurement and the second shall not exceed 5 deg F (minus 15 deg C).
  9. Internal conduit and elbow walls shall be smooth, and all fibers embedded in the epoxy.
  10. Conduit, elbows, and fittings shall be manufactured in the United States and marked as such.
- B. RTRC Fiberglass Fittings:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Champion Fiberglass, Inc.; RTRC fiberglass fittings or comparable product.
  2. Fiberglass conduit fittings, elbows, and accessories shall be manufactured using one of two manufacturing procedures.
    - a. First method shall use the same process, methods, and components as used to manufacture the fiberglass conduit.
    - b. Second method shall use the compression molding process, SMC, for the manufacture of the finished component.
    - c. SMC material shall be a vinyl ester resin with plus 30 percent reinforcement of glass.
    - d. Glass fibers should be approximately 1 inch (25 mm) in length. SMC material shall be fire resistant to UL 2515 specifications and shall be halogen free. Plastic duct plugs shall be manufactured from PVC.
  3. All elbows shall meet the nominal radius plus or minus 2 degrees. Wall thickness shall meet tolerance as indicated below and the "Out of Rounds" as indicated in NEMA TC 14.
  4. All elbows shall have either straight ends or deep-socket PVC couplings.
  5. All conduits and elbows shall be durably and legibly marked in accordance with NEMA TC 14. In addition, the following information shall be included:
    - a. NEMA TC 14.
    - b. UL2515 AG (Above Ground).
    - c. Manufacturer and reseller (if the conduit was modified or bent other than by manufacturer).

- d. Date of manufacturing of conduit and elbows.
  - e. Elbows shall be marked with angle and radius.
  - 6. Fittings, General: Listed and labeled for type of conduit, location, and use.
  - 7. Fittings for RTRC: Comply with NEMA TC 3; match to conduit or tubing type and material.
    - a. Fittings for RTRC: Comply with UL 514B.
  - 8. Conduit, elbows, and fittings shall be manufactured in the United States and marked as such.
  - 9. Solvents and Adhesives: As recommended by conduit manufacturer.
- C. RTRC Joining System:
- 1. Conduit Subjected to Changes in Ambient Temperature:
    - a. Conduit shall be supplied with a bonded coupling or an integral wound bell on one end and a machined spigot on the other end.
      - 1) A two-part adhesive, epoxy resin system, designed to permanently bond fittings and joints of conduit shall be properly mixed and applied to the spigot end before joining the conduits together.
      - 2) Adhesive shall be available for use in three different ambient temperatures, 70, 40, and 20 deg F (plus 21, plus 4.5, and minus 7 deg C).
      - 3) Surfaces must be prepared, clean, and dry prior to applying the epoxy adhesive.
      - 4) Supply adhesive from same manufacturer of conduit and fittings in order not to void the listing by UL.
  - 2. Constant Ambient Temperature - Gasketed Joining System:
    - a. Conduit shall be supplied with a gasketed joining system, which can be used for concrete encasement as well as direct-burial installations.
      - 1) This gasketed conduit shall consist of a three-ribbed gasket made from water-resistant rubber material.
      - 2) Gasket shall be fit into a permanent groove in the belled end of the conduit.
      - 3) Retainer rings, etc., are not permitted and shall not be used to create the gasket groove.
  - 3. Constant Ambient Temperature - Interference Joining System:
    - a. Conduit shall be supplied with an interference joining system, which can be used for concrete encasement (only).
      - 1) Interference joining system consists of an integral bell and spigot.
      - 2) Spigot end has a buttress type male thread for easy installation into the belled-end female mating threads.
      - 3) Tapered buttress threads make the joining system easy to assemble while providing a high pull-out strength of 1000 lb. (4448 N).
      - 4) The joining system is concrete tight, but not watertight.

## 2.4 FLEXIBLE NONMETALLIC DUCTS

### A. HDPE Duct: Type EPEC 40-HDPE complying with NEMA TC 7 and UL 651A.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - a. ARNCO Corp.
  - b. Carlon; a brand of Thomas & Betts Corporation.
  - c. National Pipe & Plastics.
  - d. Opti-Com Manufacturing Network, Inc (OMNI).
  - e. Premier Conduit.
2. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-C and TIA-758-C.

## 2.5 DUCT ACCESSORIES

### A. Rigid Innerduct: Smooth or Corrugated HDPE duct, orange in color, designed for installation within a duct or pathway, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - a. Blue Diamond Industries.
  - b. Carlon; a brand of Thomas & Betts Corporation.
  - c. Dura-Line.
  - d. Eastern Wire.
  - e. Endot Industries Inc.
  - f. Opti-Com Manufacturing Network, Inc (OMNI).
  - g. Premier Conduit.
  - h. Thomas & Betts Corporation; A Member of the ABB Group.

### B. Fabric Innerduct: Continuous, polyester, single or multi-pocket fabric innerduct, with internal pull tape and tracer wire, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.

1. Manufacturers: Subject to compliance with requirements, provide products by the following, or an approved equal:
  - a. Maxcell.

### C. 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.

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

- a. Allied Tube & Conduit; a part of Atkore International.
- b. CANTEX INC.
- c. Carlon; a brand of Thomas & Betts Corporation.
- d. IPEX USA LLC.
- e. PenCell Plastics.
- f. Underground Devices, Inc.

- D. Underground-Line Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

## 2.6 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Description: Monolithically poured, factory-fabricated, reinforced-concrete 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, or an approved equal:
- 1. Christy Concrete Products.
  - 2. Elmhurst-Chicago Stone Co.
  - 3. Oldcastle Precast, Inc.
  - 4. Rinker Group, Ltd.
  - 5. Riverton Concrete Products.
  - 6. Utility Concrete Products, LLC.
  - 7. Utility Vault Co.
  - 8. Wausau Tile Inc.
- 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. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- F. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
- 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- G. Frame and Cover: Weatherproof aluminum frame, with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
- 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- H. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- I. Cover Legend: Molded lettering, "COMMUNICATIONS" or "COMM".

- J. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- K. Extensions and Slabs: Designed to mate with bottom of enclosure and made of 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.
- L. 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.
- M. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct and duct banks, plus an additional **12 inches (300 mm)** vertically and horizontally to accommodate alignment variations.
  - 1. 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.
  - 2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct banks.
  - 3. Knockout panel openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
  - 4. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
- N. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
  - 1. Type and size shall match fittings to duct or conduit to be terminated.
  - 2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
- O. 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.

## 2.7 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal:
  - 1. Armorcast Products Company.
  - 2. MacLean Highline.
  - 3. NewBasis.
  - 4. Oldcastle Enclosure Solutions.
  - 5. Quazite: Hubbell Power Systems, Inc.

- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Green.
- E. Configuration: Units shall be designed for flush burial and have open or closed bottom unless otherwise indicated, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- 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, "COMMUNICATIONS" or "COMMJ".
- 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.

## 2.8 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER

- A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. Armorcast Products Company.
  - 2. Christy Concrete Products.
  - 3. NewBasis.
  - 4. Oldcastle Enclosure Solutions.
  - 5. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Green.
- E. Configuration: Units shall be designed for flush burial and have open or closed bottom unless otherwise indicated, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- 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, "**COMMUNICATIONS**" or "**COMM**".
- 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.

## 2.9 FIBERGLASS HANDHOLES AND BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. Christy Concrete Products.
  - 2. MacLean Highline.
  - 3. Nordic Fiberglass, Inc.
  - 4. Oldcastle Enclosure Solutions.
  - 5. Quazite: Hubbell Power Systems, Inc.
- B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- C. Color: Green.
- D. Configuration: Units shall be designed for flush burial and have open or closed bottom unless otherwise indicated, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- G. Cover Legend: Molded lettering, "COMMUNICATIONS" or "COMM".
- H. 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.
- I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- J. 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.

## 2.10 HIGH-DENSITY PLASTIC BOXES

- A. Description: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be made of polymer concrete.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. Nordic Fiberglass, Inc.
  - 2. Oldcastle Enclosure Solutions.
  - 3. PenCell Plastics.
  - 4. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Green.
- E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- 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, "COMMUNICATIONS" or "COMM".
- 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.

## 2.11 PRECAST MANHOLES

- A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. Carder Concrete Products.
  - 2. Christy Concrete Products.
  - 3. Elmhurst-Chicago Stone Co.
  - 4. Oldcastle Precast, Inc.

5. Rinker Group, Ltd.
6. Riverton Concrete Products.
7. Utility Concrete Products, LLC.
8. Utility Vault Co.
9. Wausau Tile Inc.

- C. Standard: Comply with ASTM C858.
- D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
- E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
1. Splayed or Center window location, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
  2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, 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 banks.
  4. Knockout panel openings 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.
- F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct or conduit to be terminated.
  2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.
- G. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct routed from the facility.
- H. 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.

## 2.12 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for duct entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C858 and with Section 033000 "Cast-in-Place Concrete."
- C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

## 2.13 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or an approved equal:
  - 1. BILCO Company (The).
  - 2. Campbell Foundry Company.
  - 3. Carder Concrete Products.
  - 4. Christy Concrete Products.
  - 5. EJ.
  - 6. Elmhurst-Chicago Stone Co.
  - 7. McKinley Iron Works, Inc.
  - 8. Neenah Foundry Company.
  - 9. NewBasis.
  - 10. Oldcastle Precast, Inc.
  - 11. Osburn Associates, Inc.
  - 12. Pennsylvania Insert Corporation.
  - 13. Quazite: Hubbell Power Systems, Inc.
  - 14. Rinker Group, Ltd.
  - 15. Riverton Concrete Products.
  - 16. Underground Devices, Inc.
  - 17. Utility Concrete Products, LLC.
  - 18. Utility Vault Co.
  - 19. Wausau Tile Inc.
- C. 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 or cast aluminum, with milled cover-to-frame bearing surfaces; 26-inch (660-mm) or 29-inch (725-

- mm) diameter, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- 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.
  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 of 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 conforming to ASTM C990. Install sealing material in accordance with the sealant manufacturers' written instructions.
- D. Manhole Sump Frame and Grate: ASTM A48/A48M, Class 30B, gray cast iron.
- E. 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.
- F. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500 lbf (11 kN) minimum tension.
- G. 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.
- H. 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 a minimum of 1-1/4 inches (31 mm) at base.
1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- I. Ground Rod Sleeve: 3-inch (75-mm), PVC duct sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.
- J. 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.
- K. 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 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.
- L. 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 duct, metallic duct, duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- M. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder, mounting brackets, and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin, or hot-dip galvanized steel, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- N. Portable Manhole Ladders: UL-listed, heavy-duty fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). Two required.
- O. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater or Light duty, designed for lifts less than 60 lbf (270 N). Two or more as required for proper lift.

## 2.14 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures in accordance with 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. 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 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 runs drain to manholes and handholes, and as approved by Architect.

- C. Clear and grub vegetation to be removed and protect vegetation to remain in accordance with Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication in accordance with Section 311000 "Site Clearing."

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Communications: Type EPC-80-PVC or Type EPC-40-PVC RNC, in concrete-encased duct bank unless otherwise indicated, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- B. Duct for Communications: Type EPC-80-PVC or Type EPC-40-PVC RNC, in direct-buried duct bank unless otherwise indicated, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- C. Duct for Communications: Type EPEC-40-HDPE or Type EPEC-80-HDPE duct in direct-bored duct bank unless otherwise indicated, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- D. Underground Duct Crossing: Paved Parking Areas, Driveways, and Roadways Type EPC-80-PVC or Type EPC-40-PVC RNC, encased in reinforced concrete, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- E. Stub-Ups for Communications: Concrete-encased GRC or PVC-coated GRC, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.

### 3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for Communications:
  - 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: Polymer concrete, SCTE 77, Tier 15 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. Units Subject to Light-Duty Pedestrian Traffic Only: High-density plastic, structurally tested in accordance with SCTE 77 with 3000-lbf (13 345 N) vertical loading.
  - 5. Cover design load shall not exceed the design load of the handhole or box.
- B. Manholes: Precast or cast-in-place concrete.
  - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating in accordance with AASHTO HB 17.
  - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating in accordance with 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 immediately after backfilling is completed or after construction in immediate area is complete, as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated.
- 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 utility structures in accordance with the "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 configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct and duct bank in accordance with NEMA TCB 2 and TIA-758-C.
- C. Slope: Pitch duct and duct bank a minimum slope of 1:100 down toward manholes and handholes and away from buildings and equipment. Slope duct and duct bank from a high point in runs 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 **48 inches (1200 mm)**, both horizontally and vertically, at other locations unless otherwise indicated.
  - 1. Duct and duct banks 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 in accordance with manufacturer's written instructions. Stagger couplings, so those of adjacent ducts do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct or duct banks are installed parallel to underground steam lines, perform calculations showing the duct or duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to

rise above 40 deg C, and anywhere the duct or duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

- G. End-Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, 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 end-bell spacing 10 ft. (3 m) from the end bell without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight-line direct-buried duct and duct banks, with calculated expansion of more than 3/4 inch (19 mm).
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. 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 ft. (3 m) from the terminator without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight-line duct or duct bank, with calculated expansion of more than 3/4 inch (19 mm).
- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 ft. (3 m) outside the building wall, without reducing duct slope away from the building or forming a trap in the duct.

Use fittings manufactured for RNC duct-to-GRC conduit transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

- J. Sealing: Provide temporary closure at terminations of duct that has cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15 psig (1.03 MPa) hydrostatic pressure.
- K. Innerduct: Install immediately after mandreling duct. Size and type as indicated on Drawings, or as necessary per project documentation, codes, manufacturer, and provider specifications, or other. Provide three innerducts per duct, minimally.
- L. Pulling Cord: Install 200 lbf- (1000 N) test nylon cord in empty duct and innerduct.
- M. Concrete-Encased Duct and Duct Bank:
  - 1. Excavate trench bottom to provide firm and uniform support for duct or duct bank. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
  - 2. Width: Excavate trench 12 inches (300 mm) wider than duct or duct bank on each side.
  - 3. Width: Excavate trench 3 inches (75 mm) wider than duct or duct bank on each side.
  - 4. Depth: Install top of duct and duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
  - 5. Support duct and duct bank on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
  - 6. Minimum Space between Duct: 3 inches (75 mm) between edge of duct and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and communications ducts.
  - 7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft. (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 duct to prevent floating during concreting. Tie entire assembly together using fabric

- straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around duct or duct bank.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct run unless otherwise indicated. Extend concrete encasement throughout length of elbow.
  9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
    - a. Couple GRC to duct 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 minimum 4 inches (100 mm) above finished floor and minimum 3 inches (75 mm) from conduit side to edge of slab.
    - c. Stub-ups to Indoor Equipment: Extend concrete-encased 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 minimum 4 inches (100 mm) above finished floor and no less than 3 inches (75 mm) from conduit side to edge of wall.
  10. Reinforcement: Reinforce concrete-encased duct and duct bank where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
  11. Forms: Use trench walls to form side walls of duct and duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
  12. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between ducts, and 4 inches (100 mm) between power and communications duct.
  13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed in accordance with manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
    - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
  14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between ducts and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto duct. Allow concrete to flow to center of bank and rise up in middle, uniformly filling

all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

N. Direct-Buried Duct and Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct and duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for duct less than 6 inches (150 mm) in nominal diameter.
2. Install duct with a minimum of 3 inches (75 mm) between duct for like services and 6 inches (150 mm) between power and signal duct.
3. Width: Excavate trench 12 inches (300 mm) wider than duct or duct bank on each side.
4. Width: Excavate trench 3 inches (75 mm) wider than duct or duct bank on each side.
5. Depth: Install top of duct or duct bank at least 36 inches (900 mm) below finished grade unless otherwise indicated.
6. Set elevation of bottom of duct or duct bank below frost line and as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
7. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
8. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft. (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 duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around duct or duct bank.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances through floor, and at changes of direction in duct unless otherwise indicated. Encase elbows for stub-ups throughout length of elbow. Extend encasement minimum of 36 inches (900 mm) beyond elbow joints.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
  - a. Couple GRC to duct with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete.
  - b. For equipment mounted on outdoor bases, extend GRC horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving duct 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 duct 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 of 3 inches (75 mm) of sand as a bed for duct and duct bank. Place sand to a minimum of 6 inches (150 mm) above top level of duct and duct bank.
  - b. Place minimum of 6 inches (150 mm) of engineered fill above concrete encasement of duct bank.
- O. Underground-Line Warning Tape: Bury conducting underground-line warning tape specified in Section 260553 "Identification for Communication Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct bank[ 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. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

#### B. 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.

#### C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (380 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 and as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
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.

#### D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

#### E. 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.

#### F. Waterproofing: Apply waterproofing to exterior surfaces, per manufacturer or job requirements, of manholes and handholes after concrete has cured at least three days. After duct has been connected

and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

- G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days, per manufacturer or job requirements. After duct has been connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- H. Hardware: 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.
- I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- J. 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 field-installed anchor bolts installed. 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 duct bank, 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 and as necessary per project documentation, codes, manufacturer, and provider specifications, or other.
- 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 in accordance with 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).

### 3.8 GROUNDING

- A. Ground underground duct, duct bank, and utility structures in accordance with Section 260526 "Grounding and Bonding for Electrical Systems" and Section 270526 "Grounding and Bonding for Communications Systems."

### 3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
  - 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" and Section 270526 "Grounding and Bonding for Communications Systems."

- B. Correct deficiencies and retest as specified above to demonstrate compliance.

### 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 as necessary 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.

END OF SECTION 270543

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## SECTION 27 05 44 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.
- B. Related Requirements:
  - 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

#### 1.3 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Wall Sleeves:
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
  - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized-steel sheet.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.

## 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Advance Products & Systems, Inc.
    - b. CALPICO, Inc.
    - c. HOLDRITE.
    - d. Metraflex Company (The).
    - e. Pipeline Seal and Insulator, Inc.
    - f. Proco Products, Inc.
  - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Carbon steel.
  - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. HOLDRITE.

## 2.4 GROUT

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

- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
  - 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.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
  - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.

2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

- E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 27 05 44

## SECTION 271000 - STRUCTURED CABLE SYSTEM

### 1.1 STIPULATIONS

- A. The specification sections "General Conditions of Contract", "Special Conditions" and "Division 1 – General Requirements" form a part of this section by this reference thereto, and shall have the same force and effect as if printed herewith in full.

### 1.2 SUMMARY

- A. The Work of this Section includes all labor, materials and equipment to provide the Communications System components stated below:
  - 1. Backbone Cable
  - 2. Horizontal Cable
  - 3. Termination Hardware
  - 4. Faceplates and Connectors
  - 5. Connecting Cords, Devices and Adapters

### 1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Contractor shall comply with the most recent edition of the referenced Codes and Standards, unless otherwise noted.
- C. NFPA 70 National Electrical Code
- D. Harris Site Grounding and Lightning Protection Guidelines
- E. Motorola R56 – Standards and Guidelines for Communications Sites, latest issue
- F. NFPA 70 National Electrical Code
- G. ANSI/TIA-568-E - Series - Generic Telecommunications Cabling for Customer Premises
- H. ANSI/TIA 569-E Telecommunications Pathways and Spaces
- I. ANSI/TIA-606-C Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
- J. ANSI/TIA-607-D Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- K. ANSI/TIA-942-B Telecommunications Infrastructure Standard for Data Centers
- L. ANSI/BICSI-002-2019 – Data Center Design and Implementation Best Practices
- M. BICSI Telecommunications Distribution Methods Manual (TDMM), most recent issue.
- N. Section 260500 General Requirements for Electrical Work
- O. Section 260533 Raceways and Boxes for Electrical Systems

- P. Section 260526 Grounding and Bonding
- Q. Section 262726 Wiring Devices and Wall Plates
- R. Section 270508 Pathway for Communications Systems
- S. Section 271116 Equipment Rooms and Fittings - Communications

#### 1.4 DEFINITIONS

- A. Consolidation Point - an assembly consisting of a NEMA 1 rated enclosure and Category Rated 100-style termination block(s) for interconnecting and outside plant Category Rated Cable to inside plant Category Rated cable. The consolidation point is installed above the ceiling in the area of slab on grade floor boxes. Conduits are installed from the slab on grade floor boxes to the consolidation point. The cables are interconnected on the 110-style termination blocks. Cable testing is performed using the inside plant rated cable performance characteristics.
- B. Equipment Cords – flexible cords with like or dissimilar connectors at either end for connecting between a work area or equipment outlet to installed equipment (e.g.: wireless access point; fire alarm control panel; security control panel; building automation panel, etc.).
- C. Equipment Outlets - telecommunications outlets installed inside or adjacent to equipment to be installed by this Contractor or by another trade (e.g.: wireless access point, fire alarm control panel, security control panel; building automation panel, elevator telephone, etc.).
- D. Patch Cords – flexible cords with like or dissimilar connectors at either end for connecting between patch panels and from patch panels to rack mount equipment in communications spaces (e.g. network switches, routers, etc.)
- E. Work Area Cords – flexible cords with like or dissimilar connectors at either end for connecting between work area outlets and End Users provided equipment in the work area (e.g.: computers, printers, copiers, telephones, etc.)
- F. Work Area Outlet - telecommunications outlets installed in offices, modular furniture, floor boxes, etc. for connection of computers and equipment to be installed by the End Users (e.g.: computers, printers, copiers, telephones, etc.). Work area outlet plates include wall mount outlets, wireless access point outlets, furniture mount outlets, floor mount outlets (all types), wall-phone outlets, wet/damp location outlets and similar outlet locations.

#### 1.5 SUBMITTALS

- A. All submittals shall be submitted for review and approval in accordance with the Division 1 Requirements.
  - 1. Submit product data in accordance with Division 1 Requirements.
  - 2. Submit product data for each product specified in this Section.
  - 3. Submit samples in accordance with Division 1 Requirements.
    - a. Submit samples of the following for review and approval:
    - b. Connectors
    - c. Work Area Outlet Plates with affixed labels.
- B. Qualifications: Submit qualifications for the Contractor's Supervisor/Foreman responsible for installation of the system.

- C. Submit proof of Contractor's Manufacturer Certification for installation and extended warranty of the proposed cable system immediately following issuance of notice to proceed.
- D. As-Built Record Documents: Following completion of the system installation, provide a complete set of as-built documents including, but not limited to the following:
- E. Complete Record Drawings: Showing locations, size and configuration of all components, devices and equipment.
  - 1. As-built one-line schematic diagrams.
  - 2. Detailed as-built drawings.
  - 3. Final Inspection and Test Report:
    - a. Test procedure used.
    - b. Record of any failed tests and corrective action taken, resulting in compliant test results.

#### 1.6 COORDINATION

- A. Coordinate exact location of all outlets with End Users, and the work of other trades prior to rough-in.
- B. Coordinate the location of all floor outlets, modular furniture feed outlets and wall outlets with the Architect and furniture plans prior to rough-in.
- C. Coordinate connections between patch panels with End Users prior to installation of patch cords.
- D. Coordinate connections between patch panels and equipment with the End Users prior to installation of patch cords.
- E. Coordinate exact location rough-ins for modular furniture systems with the Architect and End Users prior to rough-in.
- F. Coordinate location of and connection to equipment of other trades with Contractor responsible for equipment installation prior to rough-in of equipment outlets.
- G. Coordinate cross-connect and telephone circuit requirements with the End Users and the equipment installers prior to rough-in.

#### 1.7 QUALITY ASSURANCE

- A. Quality assurance requirements as defined in Division 1 requirements and as follows:
- B. All products shall be Listed for the specific application intended as part of this Work.
- C. All products shall be Listed and Labeled by UL or another Nationally Recognized Test Laboratory (NRTL).
- D. At a minimum, the Contractor's Supervisor/Foreman, responsible for this installation of the Work of this Section, shall be trained by the manufacturer for installation of the products installed as part of the Work.

#### 1.8 DELIVERY, STORAGE AND HANDLING

- A. All products shall be delivered to site in the original manufacturer's packaging, distributors packaging or other packaging suitable for protection of the materials.

- B. All products stored off-site and on-site shall be maintained in a manner to protect the materials from weather, corrosion or damage.
- C. All products shall be stored in a secure location under the direct control of the Contractor.
- D. All products shall be handled as recommended by the Manufacturer.
- E. Any products exhibiting evidence of damage, corrosion or defect shall be removed from site and replaced at no additional cost to the End Users.

#### 1.9 TRAINING

- A. After completion of the system installation, the Contractor shall provide training to the End Users on proper methods to inspect, test and maintain the installed system.
- B. The training shall include recommendations for an inspection, testing and maintenance program to be performed by the End Users over the expected lifetime of the system.

#### 1.10 WARRANTY

- A. Provide a warranty as required by Division 1 and as indicated herein.
- B. Structured cable system components from separate manufacturers (e.g. cables and termination hardware) shall be manufacturer tested as an end-to-end solution and verified as an end-to-end solution by a Nationally Recognized Testing Laboratory (NRTL) to meet or exceed all performance requirements as specified in the Standards listed.
- C. Provide a minimum 20-year cable system link performance warranty for the backbone and horizontal distribution cable systems installed as part of the Work. Provide a minimum 15-year warranty on all cable, connectors and termination hardware included as part of the Work, and not otherwise covered by the system performance warranty. Contractor shall be a Manufacturer Certified Contractor for the cable system(s) proposed at the time bids are submitted. Submit proof of Contractor's Manufacturer Certification for installation and extended warranty of the proposed cable system immediately following issuance of notice to proceed.

### PART 2 - PART 2 – PRODUCTS

#### 2.1 DESIGN BASIS MANUFACTURERS

- A. Products from the following manufacturers generally conform to the specific design basis for the Work. Subject to product compliance with the requirements of the Construction Documents, acceptable Manufacturer's include, but are not limited to:
  - 1. Corning Cable Systems
  - 2. Superior Essex
  - 3. General Cable
  - 4. Berk-Tek
  - 5. CommScope
  - 6. Mohawk
  - 7. Hubbell

8. Leviton
  9. Panduit
  10. Ortronics
  11. The Siemon Company
- B. All products provided as part of this Work shall be Listed for their intended use by a Nationally Recognized Testing Laboratory (NRTL).
- C. All products shall be Listed for their specific types, sizes and combinations of conductors and connected items.
- D. Contractor shall be responsible for selection of cable, connectors and termination hardware as required to provide extended warranties as required by the Construction Documents.

## 2.2 SINGLE-MODE OPTICAL FIBER

- A. Design Basis Product: Corning SMF-28e+ Optical Fiber, or approved equal
- B. Mode Field Diameter:
1. 1310 nm: 9.2 +/- 0.4 micron
  2. 1550 nm: 10.4 +/- 0.5 micron
- C. Dispersion:
1. 1550 nm:  $\leq 18.0$  ps/(nm<sup>2</sup>-km)
  2. 1625 nm:  $\leq 22.0$  ps/(nm<sup>2</sup>-km)
- D. Point Discontinuity:
1. 1310 nm:  $\leq 0.05$  dB
  2. 1550 nm:  $\leq 0.05$  dB
- E. Attenuation:
1. 1310 nm: 0.35 dB/km, maximum
  2. 1383 nm: 0.35 dB/km, maximum
  3. 1490 nm: 0.24 dB/km, maximum
  4. 1550 nm: 0.20 dB/km, maximum
  5. 1625 nm: 0.23 dB/km, maximum
- F. Macrobend Loss:

Mandrel Radius (mm)	Number of Turns	Wavelength (nm)	Induced Attenuation (dB)
32	1	1550	$\leq 0.03$
50	100	1310	$\leq 0.03$
50	100	1550	$\leq 0.03$
60	100	1625	$\leq 0.03$

- G. Glass Geometry:

1. Core Diameter: 8.2 micron
2. Cladding Diameter: 125.0 +/- 0.7 micron
3. Core-Clad Concentricity: <= 0.5 micron
4. Cladding Non-Circularity: >= 0.7%

H. Coating Geometry:

1. Coating Diameter: 242 +/- 5 micron
2. Coating-Cladding Concentricity: <12 micron

I. Environmental:

Environmental Test	Test Condition	Induced Attenuation 1310nm, 1550nm and 1625nm (dB/km)
Temperature Dependence	-60 degrees C to +85 degrees C	<= 0.05
Temperature Humidity Cycling	-10 degrees C to +85 degrees C and up to 98% RH	<= 0.05
Water Immersion	23 degrees C +/- 2 degrees C	<= 0.05
Heat Aging	85 degrees C +/- 2 degrees C	<= 0.05

J. Operating Temperature Range: -60 degrees C to 85 degrees C.

K. Proof Test: >= 100 kpsi, minimum

## 2.3 MULTI-MODE OPTICAL FIBER

A. Design Basis Product: Corning ClearCurve OM4 Multi-mode Optical Fiber, or approved equal

B. Optimized Data Rates and Supported Distances:

1. 1 Gbps - >1000 m
2. 10 Gbps - >300 m
3. 40/100 Gbps - >140m

C. Fiber Type: 50/125, OM4 (ISO/IEC 60793-1-49), ITA/EIA 455-220A

D. Effective Modal Bandwidth:

1. 850 nm: 3500 MHz/km
2. 1300 nm: 500 MHz/km

E. Attenuation:

1. 850 nm: <= 2.3 dB/km, maximum
2. 1300 nm: <= 0.6 dB/km, maximum

F. Macrobend Loss:

Mandrel Radius (mm)	Number of Turns	Induced Attenuation (dB) @ 850nm	Induced Attenuation (dB) @ 1300nm
15	2	$\leq 0.1$	$\leq 0.3$
7.5	2	$\leq 0.2$	$\leq 0.5$

G. Glass Geometry:

1. Core Diameter: 50.0 +/- 2.5 micron
2. Cladding Diameter: 125.0 +/- 1.0 micron
3. Core-Clad Concentricity:  $\leq 1.5$  micron
4. Cladding Non-Circularity:  $\geq 1.0\%$
5. Core Non-Circularity:  $\leq 5\%$

H. Coating Geometry:

1. Coating Diameter: 242 +/- 5 micron
2. Coating-Cladding Concentricity:  $< 12$  micron

I. Environmental:

Environmental Test	Test Condition	Induced Attenuation 850nm & 1300 nm (dB/km)
Temperature Dependence	-60 degrees C to +85 degrees C	$\leq 0.10$
Temperature Humidity Cycling	-10 degrees C to +85 degrees C and 4% to 98% RH	$\leq 0.10$
Water Immersion	23 degrees C +/- 2 degrees C	$\leq 0.20$
Heat Aging	85 degrees C +/- 2 degrees C	$\leq 0.20$
Damp Heat	85 degrees C at 85% RH	$\leq 0.20$

J. Operating Temperature Range: -60 degrees C to 85 degrees C.

K. Proof Test:  $\geq 100$  kpsi, minimum

## 2.4 OUTSIDE PLANT OPTICAL FIBER BACKBONE CABLE - ISP/OSP DIELECTRIC

- A. For installation in outside plant duct and conduit applications
- B. Design Basis Product: Corning Cable Systems - FREEDM Gel-Free Cable, or approved equal
- C. Cable Construction: Tight buffer, all dielectric
- D. Fiber Type: As indicated on drawings
- E. Fiber Count: As indicated on drawings
- F. Buffer Tube Diameter: 2.5 mm
- G. Water Blocking Material: Water-swellaable tape
- H. Strength Member: Dielectric, aramid fiber or epoxy glass rod

- I. Outer jacket Material: Flame retardant, UV resistant, plenum rated OFNP
- J. Cable Tensile Strength
  - 1. Short-term: 2700 N (600 lbf)
  - 2. Long-term: 890N (200 lbf)
- K. Weight: 49 pounds/1000 ft
- L. Outer Diameter: 0.5", maximum
- M. Minimum Bend Radius:
  - 1. Installation: 6.2"
  - 2. Operation: 4.1"
- N. Temperature Range:
  - 1. Storage: -40 degrees F to 158 degrees F
  - 2. Installation: -22 degrees F to 158 degrees F
  - 3. Operation: -40 degrees F to 158 degrees F
- O. Compliance:
  - 1. ANSI/ICEA S-87-640
  - 2. RoHS

## 2.5 INSIDE PLANT OPTICAL FIBER BACKBONE CABLE

- A. Design Basis Product: Corning Cable Systems – Plenum Rated MIC Distribution Cable, or approved equal
- B. For installation between cabinets in the main equipment room.
- C. Cable Construction: Tight buffered, all dielectric
- D. Fiber Type: As indicated on drawings
- E. Fiber Count: As indicated on drawings
- F. Strength Member: Aramid yarn
- G. Outer jacket Material: Flame retardant PVC
- H. UL Listed Flame Rating: OFNP
- I. Outer Jacket Color:
  - 1. Multimode: Aqua
  - 2. Single mode: Yellow
  - 3. Composite (SM/MM): Orange
- J. Cable Tensile Strength
  - 1. Short-term: 440 N (100 lbf)
  - 2. Long-term: 132N (30 lbf)
- K. Minimum Bend Radius:

1. Installation: 20 times cable outside diameter
2. Operation: 10 times cable outside diameter
- L. Temperature Range:
  1. Storage: -40 degrees F to 158 degrees F
  2. Installation: 32 degrees F to 140 degrees F
  3. Operation: 32 degrees F to 158 degrees F
- M. Compliance:
  1. NEC OFNP
  2. ICEA S-83-5960
  3. RoHS

## 2.6 INSIDE PLANT OPTICAL FIBER BACKBONE CABLE, ARMORED

- A. Design Basis Product: Corning Cable Systems – Plenum Rated MIC Armored Cable, or approved equal
- B. For installation in cable trays from the main distribution frame to the intermediate distribution frames.
- C. Cable Construction: Tight buffered, interlocking armor
- D. Fiber Type: As indicated on drawings
- E. Fiber Count: As indicated on drawings
- F. Strength Member: Aramid yarn
- G. Outer jacket Material: Flame retardant PVC
- H. UL Listed Flame Rating: OFCP
- I. Outer Jacket Color:
  1. Multimode: Aqua
  2. Single mode: Yellow
  3. Composite (SM/MM): Orange
- J. Cable Tensile Strength
  1. Short-term: 440 N (100 lbf)
  2. Long-term: 132N (30 lbf)
- K. Minimum Bend Radius:
  1. Installation: 20 times cable outside diameter
  2. Operation: 10 times cable outside diameter
- L. Temperature Range:
  1. Storage: -40 degrees F to 158 degrees F
  2. Installation: 32 degrees F to 140 degrees F

3. Operation: 32 degrees F to 158 degrees F

M. Compliance:

1. NEC OFCP
2. ICEA S-83-5960
3. RoHS

2.7 INSIDE PLANT MULTI-PAIR UTP COPPER BACKBONE CABLE

- A. Design Basis Product: Superior Essex – Category 3 Plenum, or approved equal
- B. Conductors: 24 AWG, solid, annealed copper
- C. Pair Count: As indicated on drawings
- D. Insulation: Flame retardant PVC
- E. Insulation Color Code: In accordance with telephone industry standards
- F. Core Assembly:
  1. 25 Pairs and Less: Single group
  2. > 25 Pairs: 25 pair groups, color coded unit binder
- G. Jacket: Flame retardant PVC
- H. Weight: 1142 pounds/1000 ft., maximum (25-pair)
- I. Outer Diameter: 0.43", nominal (25-pair)
- J. Minimum Bend Radius:
  1. Installation: 10 times cable outside diameter
  2. Operation: 4 times cable outside diameter
- K. Temperature Range:
  1. Installation: 0 degrees C to 60 degrees C
  2. Operation: -20 degrees C to 75 degrees C
- L. Compliance:
  1. NEC CMP
  2. ANSI/TIA 568-C.2
  3. RoHS

2.8 INSIDE PLANT COAXIAL FLEXIBLE BACKBONE CABLE

- A. Design Basis Product: Commscope 2287V, RG-11 Quad Shield, Plenum Rated Cable, or equal
- B. Center Conductor: Copper-clad steel
- C. Dielectric Material: Foamed FEP
- D. Quad Shield Construction:
  1. Bonded aluminum poly tape

2. 60% tinned copper, 36 AWG wire
  3. Non-bonded aluminum poly tape
  4. 50% tinned copper, 36 AWG wire
- E. Jacket Material: Fire retardant PVC (CMP rated)
- F. Center Conductor Gauge: 14 AWG
- G. Center Conductor Diameter: 0.0641 inch
- H. Dielectric Diameter: 0.278 inch
- I. Inner Shield Tape Diameter: 0.284 inch
- J. Outer Jacket Diameter: 0.356 inch
- K. DC Resistance:
1. Center Conductor: 11.0 ohms/kft
  2. Quad Shield: 1.70 ohms/kft
- L. Nominal Velocity of Propagation: 86%
- M. Characteristic Impedance: 75 ohm
- N. Operating Frequency: 5-2200 MHz
- O. Structural Return Loss: 15 dB @ 1000-3000 MHz, 20 dB @ 5-1000 MHz, 100% sweep tested
- P. Minimum Bend Radius:
1. Loaded: 20 times outside diameter
  2. Unloaded: 10 times outside diameter
- Q. UL Listed: CATVP/CMP
- R. Compliance: RoHS
- S. Electrical Performance:

Frequency (MHz)	Attenuation (dB/100 ft)
1	0.15
10	0.45
50	0.90
100	1.28
200	1.85
400	2.75
700	3.92
900	4.72
1000	5.04
1450	6.67
1800	7.71
2200	8.50
3000	9.88

2.9 CATEGORY 6A RATED UTP COPPER HORIZONTAL DISTRIBUTION CABLE

- A. Design Basis Product: Superior Essex – 10Gain XP Category 6A CMP, or approved equal
- B. Cable Construction:
  - 1. Four-pair unshielded twisted pair
  - 2. Cross-web separator
  - 3. Non-conductive isolation wrap
- C. Conductors: 23 AWG solid annealed copper
- D. Insulation Material: FEP (CMP rated)
- E. Jacket Material: Fire retardant, low-smoke PVC
- F. Outside Diameter: 0.295", nominal
- G. Characteristic Impedance: 100 ohms +/- 15 ohms
- H. Velocity of Propagation: 69%, nominal
- I. Alien Cross-talk Isolation: 3 dB greater than ANSI/TIA-568-E requirements
- J. Performance Compliance: ANSI/TIA-568-E
- K. Performance tested to 500 MHz
- L. Minimum Bend Radius: 1.2"
- M. Compliance:
  - 1. NEC CMP
  - 2. ANSI/TIA 568-C.2
  - 3. RoHS
- N. NRTL Programs:
  - 1. UL Verified Cat 6A

2.10 CATEGORY 6A RATED UTP COPPER HORIZONTAL DISTRIBUTION CABLE – WET/DAMP LOCATION

- A. Design Basis Product: Superior Essex – OSP Broadband Category 6A, or approved equal
- B. For use in slab on grade outlets and cables installed in slab-on grade raceways.
- C. Cables shall be transitioned to plenum rated cables in a consolidation point above accessible ceiling
- D. Contractor shall bond the cable screen to ground in the outlet box and in the consolidation point.
- E. Contractor shall extend an insulated ground conductor from the consolidation point to the serving telecommunications room for this purpose, size conductor per Motorola R56.
- F. Cable Construction:
  - 1. Four-pair screened twisted pair

2. Cross-web separator
3. Gel-filled, water repellent core
4. Polyethylene inner jacket
5. Powder or yarn dry water block
6. Aluminum tape shield
7. Polyethylene outer jacket
- G. Conductors: 23 AWG solid annealed copper
- H. Insulation Material: Polyolefin
- I. Jacket Material: Sunlight and weather resistant polyethylene
- J. Outside Diameter: 0.39", nominal
- K. Characteristic Impedance: 100 ohms +/- 15 ohms
- L. Velocity of Propagation: 68%, nominal
- M. Performance Compliance: ANSI/TIA-568-E
- N. Performance tested to 500 MHz
- O. Compliance:
  1. NEC CMP
  2. ANSI/TIA 568-E
  3. RoHS
- P. NRTL Programs:
  1. UL Verified Cat 6A

## 2.11 CATEGORY 6 RATED UTP COPPER HORIZONTAL DISTRIBUTION CABLE

- A. Design Basis Product: Superior Essex – NextGain Category 6eX CMP, or approved equal
- B. Cable Construction:
  1. Four-pair unshielded twisted pair
  2. Cross-web separator
- C. Conductors: 23 AWG solid annealed copper
- D. Insulation Material: FEP (CMP rated)
- E. Jacket Material: Fire retardant, low-smoke PVC
- F. Outside Diameter: 0.295", nominal
- G. Characteristic Impedance: 100 ohms +/- 15 ohms
- H. Velocity of Propagation: 75%, nominal
- I. Near-end Cross-talk Isolation: 6 dB greater than ANSI/TIA-568-C.2 requirements
- J. Attenuation to Cross-talk Ratio:
  1. 30 dB at 100 MHz

- 2. 11.7 dB at 250 MHz
  - K. Performance Compliance: ANSI/TIA-568-E
  - L. Performance tested to 250 MHz
  - M. Minimum Bend Radius: 1.2"
  - N. Compliance:
    - 1. NEC CMP
    - 2. ANSI/TIA 568-E
    - 3. RoHS
  - O. NRTL Programs:
    - 1. UL Verified Cat 6
- 2.12 CATEGORY 6 RATED UTP COPPER HORIZONTAL DISTRIBUTION CABLE – WET/DAMP LOCATION
- A. Design Basis Product: Superior Essex – OSP Broadband Category 6, or approved equal
  - B. For use in slab on grade outlets and cables installed in slab-on grade raceways.
  - C. Cables shall be transitioned to plenum rated cables in a consolidation point above accessible ceiling
  - D. Contractor shall bond the cable screen to ground in the outlet box and in the consolidation point.
  - E. Contractor shall extend an insulated ground conductor from the consolidation point to the serving telecommunications room for this purpose, conductor size per Motorola R56.
  - F. Cable Construction:
    - 1. Four-pair screened twisted pair
    - 2. Cross-web separator
    - 3. Gel-filled, water repellent core
    - 4. Polyethylene jacket
  - G. Conductors: 23 AWG solid annealed copper
  - H. Insulation Material: Polyolefin
  - I. Jacket Material: Sunlight and weather resistant polyethylene
  - J. Outside Diameter: 0.30", nominal
  - K. Characteristic Impedance: 100 ohms +/- 15 ohms
  - L. Velocity of Propagation: 68%, nominal
  - M. Performance Compliance: ANSI/TIA-568-E
  - N. Performance tested to 250 MHz
  - O. Compliance:
    - 1. NEC CMP
    - 2. ANSI/TIA 568-E

3. RoHS

P. NRTL Programs:

1. UL Verified Cat 6

2.13 OPTICAL FIBER CONNECTORS

A. Design Basis Product:

1. Corning Cable Systems – UniCam Connectors, or approved equal
2. Corning Cable Systems – Epoxy Polish Connectors, or approved equal

B. Contractor may provide no-epoxy type connectors for field termination of fibers to 900 micron buffered multimode fiber strands in fiber termination enclosures and outlet boxes.

C. Termination of 250 micron coated fiber strands shall be made with epoxy type connectors or fusion splicing to factory assembled pigtails.

D. No-epoxy connectors shall have a factory assembled and polished fiber stub in the connector ferrule.

E. Termination of angle polished connectors shall be by fusion splicing to factory assembled pigtails.

F. Connectors for factory assembled pigtails shall meet or exceed the connector requirements as specified herein.

G. Connector Type:

1. Duplex LC: for multimode connections.
2. Simplex LC/APC: for single mode fiber connections.

H. Connector Ferrule: Ceramic

I. Fiber Type:

1. Multimode: OM3/OM4 50 micron core
2. Single mode: 8.2 micron core

J. Insertion Loss (mated pair):

1. Multi-mode Fiber: 0.1 dB, typical; 0.5 dB, maximum
2. Single mode Fiber: 0.2 dB, typical; 0.5 dB, maximum
3. Angle Polished Connector: 0.2 dB, typical; 0.5 dB, maximum

K. Reflectance:

1. Multimode:  $\leq -20$  dB
2. Single mode:  $\leq -55$  dB
3. Angle Polished Connector:  $\geq -65$  dB

L. Housing Color:

1. Single mode: Blue
2. Multimode: Aqua
3. Angle Polished Connector: Green

M. Connector Tensile Strength:

1. Jacketed Cable: 10 lb, change  $\leq 0.2$  dB, FOTP-6
2. 900 micron Buffered Fiber: 0.5 lb, change  $\leq 0.2$  dB, FOTP-6

N. Operating Temperature: -40 degrees F to 167 degrees F

O. Compliance:

1. ANSI/TIA 568-E
2. RoHS

P. Contractor shall provide cable furcation kits for direct termination of 250 micron fibers.

Q. Contractor shall provide cable furcation kits for direct termination of 900 micron fibers terminated in outlet boxes.

1. Furcation kits shall build up the fiber to a minimum of 2 mm.
2. Fiber connectors shall be sized to crimp to furcation kit jacket material

2.14 CATEGORY 6A RATED COPPER CONNECTORS

- A. Design Basis Product: Leviton eXtreme 6a Cat 6A UTP Connectors, or approved equal
- B. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed
- C. Contact Material: Copper based alloy plated with 50 microinches of gold over 100 micro-inches of nickel.
- D. Connection Type: 110 Style, insulation displacement contacts
- E. Connector Body: Keystone type
- F. Connector Body Material: High-impact, fire retardant plastic, UL 94V-0
- G. Color: As indicated on Drawings
- H. Performance Compliance: ANSI/TIA/EIA 568-E up to 500 MHz
- I. Compliance: RoHS

2.15 CATEGORY 6 RATED COPPER CONNECTORS

- A. Design Basis Product: Leviton eXtreme 6+ Cat 6 UTP Connectors, or approved equal
- B. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed
- C. Contact Material: Copper based alloy plated with 50 micro-inches of gold over 100 micro-inches of nickel.
- D. Connection Type: 110 Style, insulation displacement contacts
- E. Connector Body: Keystone type
- F. Connector Body Material: High-impact, fire retardant plastic, UL 94V-0
- G. Color: As indicated on Drawings
- H. Performance Compliance: ANSI/TIA/EIA 568-E up to 250 MHz
- I. Compliance: RoHS

2.16 WALL MOUNT AND WIRELESS ACCESS POINT OUTLET PLATES

- A. Design Basis Product: Leviton QuickPort Stainless Steel Wall-plates, or approved equal
- B. For wall mount outlets and wireless access point outlets.
- C. Faceplate Configuration: Single gang, 4-port
- D. Material:
  - 1. Faceplate: 304 stainless steel
  - 2. Connector Carrier: ABS plastic, UL 94V-O
- E. Port Count: As indicated on Drawings
- F. Port Configuration: As indicated on Drawings.
- G. Dimensions: Single Gang: 4.5" x 2.75", nominal
- H. Compliance: RoHS

2.17 WALL PHONE OUTLET PLATES

- A. Design Basis Product: Leviton QuickPort Stainless Steel Wall-plates, or approved equal
- B. Faceplate Configuration: Single gang
- C. Single port
- D. Flush mount connector
- E. Wall-phone mounting studs
- F. Material:
  - 1. Faceplate: 302 stainless steel
  - 2. Connector Carrier: ABS plastic, UL 94V-O
- G. Dimensions: Single Gang: 4.50" x 2.75", nominal
- H. Compliance: RoHS

2.18 MODULAR FURNITURE OUTLET PLATES

- A. Design Basis Product: Leviton QuickPort Modular Furniture Plates, or approved equal
- B. Faceplate Configuration: 4-port, horizontal (when used in PSAP Console Systems Furniture, provide 10-ports terminated on a patch panel)
- C. Material: ABS plastic, UL94V-0 rated.
- D. Port Count: As indicated on Drawings
- E. Port Configuration: As indicated on Drawings.
- F. Dimensions:
  - 1. Extended Depth: 3.25" x 1.76" x 0.75"
  - 2. Herman Miller: 3.65" x 2.18" x 0.25"

G. The End Users will be using existing modular furniture from a variety of manufacturers. Contractor shall coordinate specific size of modular furniture baseplate knockouts and appropriate quantities of each size prior to ordering modular furniture faceplates.

H. Compliance: RoHS

## 2.19 FURNITURE FEED OUTLET PLATES – WALL MOUNT

- A. Design Basis Product: Leviton Wallplates, or approved equal
- B. Material: 302 stainless steel
- C. Dimensions: double gang, 4.5" x 4.6"
- D. Contractor shall provide punched faceplates with liquid tight connectors and raceway to transition from wall mount furniture feed to modular furniture.
- E. Provide double gang faceplate with a 1-1/4" liquid tight flex conduit for a single furniture unit feed of up to six (6) Category rated cables.
- F. Provide double gang faceplate with a 1-1/2" liquid tight flex conduit for multiple furniture feeds for up to eight (8) Category rated cables.
- G. Liquid tight conduits shall be of sufficient length to minimize stress on the connectors, wall boxes or cables.
- H. Provide multiple furniture feeds at locations exceeding the cable quantities indicated above or where furniture configuration will not support larger liquid tight conduit sizes.
- I. Configuration:
  - 1. Punched for liquid tight connector.
  - 2. Provide liquid tight conduit from faceplate to modular furniture base plates for cable feed to furniture.
  - 3. Provide liquid tight conduit connectors at the faceplate and modular furniture baseplate.
  - 4. Provide 180 degree and 45 degree liquid tight connectors as required by furniture and outlet configuration. 90 degree liquid tight connectors shall not be used.

## 2.20 EQUIPMENT OUTLET BOXES

- A. Design Basis Manufacturer: Leviton QuickPort Surface Mount Housing
- B. For connections to equipment requiring network or telephone connections.
- C. For installation in equipment enclosures or in a NEMA 1 box adjacent to equipment enclosures.
- D. Material: High impact ABS plastic, UL94V-0 rated.
- E. Port Count: One or two port, as required by cable count.
- F. Labeling window.
- G. Color: White.
- H. Dimensions:
  - 1. 1-Port: 1.5" x 2.25" x 1.0", nominal
  - 2. 2-Port: 2.5" x 2.25" x 1.0", nominal

- I. Provide 6" x 6" x 4" NEMA 1 enclosures and conduit where equipment outlet box cannot be installed inside the equipment enclosure as described in Part 3, Execution.

#### 2.21 RAISED FLOOR BOX OUTLET PLATES

- A. Design Basis Manufacturer: As required for installation in raised floor boxes.

#### 2.22 CAST IN-PLACE FLOOR BOX OUTLET PLATES

- A. Design Basis Manufacturer: As required for installation in cast-in place floor boxes as specified in Section 16130. Coordinate with Architect and other trades for cable pathways and penetrations.
- B. Slab on grade outlets shall be installed with wet/damp location cable, however wet/damp location connectors and faceplates are not required in slab on grade outlets unless otherwise noted.

#### 2.23 POKE-THROUGH FLOOR BOX OUTLET PLATES

- A. Design Basis Manufacturer: As required for installation in poke-through floor boxes. Coordinate with Architect and other trades for cable termination spaces.

#### 2.24 WET/DAMP LOCATION OUTLET PLATES

- A. Design Basis Product: Leviton DuraPort Stainless Steel Wallplates, or approved equal
- B. For use where weather proof or wet/damp location outlet (WP) is indicated on Drawings.
- C. Provide with connectors as indicated by outlet type.
- D. Faceplate Configuration:
  - 1. Single gang: 1-port and 2-port
  - 2. Double gang: 2-port and 4-port
- E. Material:
  - 1. Faceplate: 304 stainless steel
  - 2. Connector Carrier: ABS plastic, UL 94V-O
- F. Port Count: As indicated on Drawings
- G. Port Configuration: As indicated on Drawings.
- H. Over-molded faceplate gasket
- I. Captive connector cap
- J. Dimensions:
  - 1. Single Gang: 4.5" x 2.75"
  - 2. Double Gang: 4.5" x 4.60"
- K. Environmental: IP67, dust-tight, temporary water immersion
- L. Compliance: RoHS

2.25 FIBER TERMINATION ENCLOSURES, RACK MOUNT

- A. Design Basis Product: Corning Cable Systems – Closet Connector Housing (CCH), or approved equal
- B. 19" cabinet/rack mount fiber termination enclosure
- C. Dimensions:
  - 1. Up to 24 Strands fiber: 3.5" x 17" x 17"
  - 2. Over 24 strands fiber: 7" x 17" x 17"
- D. Capacity:
  - 1. Two Rack Unit Enclosure: Four connector panels
  - 2. Four Rack Unit Enclosure: Eight connector panels
- E. Connector Panels:
  - 1. Duplex LC: 12 strands per panel
  - 2. Simplex LC: 12 strands per panel
  - 3. Multimode Fiber Adapters:
- F. Locking front and rear access
- G. Material:
  - 1. Housing: White powder coated steel
  - 2. Covers: Tinted polycarbonate
- H. Compliance: RoHS
- I. Provide with splice trays/cassettes when used with fusion spliced pigtails.
- J. Provide with slack management cassettes when used with field terminated connectors.
- K. Provide with cable strain relieve and fiber management devices.
- L. Provide with blank filler panels in all unused panel spaces.

2.26 FIBER TERMINATION ENCLOSURES, WALL MOUNT

- A. Design Basis Product: Corning Cable Systems – Industrial Connector Housing (ICH), or approved equal
- B. Wall-mount fiber termination enclosure.
- C. Dimensions: 10-1/2" high x 13" wide x 5-1/2" deep, nominal.
- D. Capacity: Two connector panels.
- E. Connector Panels: Duplex LC, 12 strands per panel.
- F. Locking termination cover.
- G. Padlock hasp on enclosure cover.
- H. Material: White powder coated steel
- I. Compliance: RoHS

- J. Provide with splice trays and splice tray holders when used with fusion spliced pigtails.
- K. Provide with cable strain relieve and fiber management devices.
- L. Provide with blank filler panels in all unused panel spaces.

#### 2.27 FIBER TERMINATION ENCLOSURES, VERTICAL MOUNT

- A. Design Basis Product: Leviton Vertigo Series, or approved equal
- B. For terminating six to twelve strands of multimode fiber inside vertical wall mount equipment cabinets.
- C. Dimensions: 10-1/2" high x 2-1/2" wide x 2-1/2" deep, nominal.
- D. Capacity: One connector panels.
- E. Connector Panels: Duplex LC, 12 strands per panel.
- F. Material: Black powder coated steel
- G. Compliance: RoHS
- H. Provide with cable strain relieve and fiber management devices.
- I. Provide with blank filler panels in all unused panel spaces.

#### 2.28 SPLICE TRAYS

- A. Design Basis Product: Corning M67 Series Splice Trays, or approved equal.
- B. For housing fusion splices in fiber termination enclosures and outdoor enclosures.
- C. Material: Aluminum body and cover
- D. Splice Chip: for housing 12 or 6 heat shrink protected fusion splices, as required
- E. Designed to support the bend radius of single-mode and multimode fiber at all wavelengths.
- F. Mounting hole for stud mounting in enclosures.
- G. Dimensions:
  - 1. 12 fiber: 11.7" x 3.9" x 0.2:
  - 2. 6 fiber: 7.3" x 3.5" x 0.2"
- H. Provide with heat shrink fusion splice protectors, quantity as required.

#### 2.29 TERMINATION BLOCKS - TELEPHONE

- A. Design Basis Product: Leviton: Cat. 6, 110-Style Cross-Connect Blocks, or approved equal
- B. For use as cross connect at telephone service provider demarcation point only.
- C. Configuration:
  - 1. Wall-mount wiring blocks with legs
  - 2. 50-pair, 100-pair or 300-pair as required
- D. Connector Blocks: 5-pair connector blocks

E. Dimensions:

1. 50-pair: 1.81" x 10.7" x 3.3"
2. 100-pair: 3.62" x 10.7" x 3.3"
3. 300-pair: 10.83" x 10.7" x 3.3"

F. Materials:

1. Fire retardant plastic, UL 94V-O
2. Insulation displacement contacts: Solder plated

G. Provide with labels and label holders

2.30 TERMINATION BLOCKS - CATEGORY RATED

- A. Design Basis Product: Leviton: Cat6A 110-Style Connecting Blocks, or approved equal
- B. For use as interconnect between outside plant rated and inside plant rated cables at Consolidation Points only.
- C. Configuration:
  1. Wall-mount wiring blocks with legs
  2. 64-pair
- D. Connector Blocks: 4-pair connector blocks
- E. Dimensions: 3.62" x 10.7" x 3.3"
- F. Materials:
  1. Fire retardant plastic, UL 94V-O
  2. Insulation displacement contacts: Solder plated
- G. Provide with labels and label holders

2.31 CROSS-CONNECT WIRE

- A. Single-pair 24-AWG plastic insulated cross-connect wire.
- B. Category 3 or higher rated performance.
- C. Blue/white color coded wires.

2.32 CLOCK AND CONTROL CIRCUIT WIRE

- A. Design Basis Manufacturer: West Penn
- B. For synchronized clock RS-485 2-wire circuit and door release dry contact circuits.
- C. Cable Construction: Two conductor, twisted, unshielded
- D. Conductors: 18 AWG stranded
- E. Insulation Material: Polymer Alloy
- F. Jacket Material: Fire retardant, low-smoke PVC

- G. Outside Diameter: 0.154", nominal
- H. Jacket Color: Gray
- I. Compliance:
  - 1. NEC CMP
  - 2. RoHS
- J. Color: White.

#### 2.33 CATEGORY 6A RATED COPPER PATCH PANELS

- A. Design Basis Product: Leviton eXtreme CAT 6A Patch Panels, or approved equal
- B. For termination of Category 6A cables in telecommunications spaces
- C. Panel Configuration: Angled
- D. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed
- E. Contact Material: Copper based alloy plated with 50 micro-inches of gold over 100 micro-inches of nickel
- F. Connection Type: 110 Style, insulation displacement contacts
- G. Connector Configuration: Printed circuit board modules
- H. Panel Material: 16 gauge steel, black powder coat
- I. Printed Circuit Board and Plastics: UL 94V-O
- J. Dimensions:
  - 1. 24-Port: 1.75" x 19" x 4.82"
  - 2. 48-port: 3.5" x 19" x 4.82"
- K. Performance Compliance:
  - 1. ANSI/TIA/EIA-568-C.2 up to 500 MHz
  - 2. IEEE 802.3an, 10GBaseT
  - 3. NRTL (ETL) Verified Category 6A component performance
- L. Compliance:
  - 1. RoHS
  - 2. UL Listed

#### 2.34 CATEGORY 6 RATED COPPER PATCH PANELS, ANGLED

- A. Design Basis Product: Leviton eXtreme CAT 6+ Patch Panels, or approved equal
- B. For termination of telecommunications and Audio/Video outlet Category 6 cables in telecommunications spaces
- C. Panel Configuration: Angled
- D. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed

- E. Contact Material: Copper based alloy plated with 50 micro-inches of gold over 100 micro-inches of nickel
- F. Connection Type: 110 Style, insulation displacement contacts
- G. Connector Configuration: Printed circuit board modules
- H. Panel Material: 16 gauge steel, black powder coat
- I. Printed Circuit Board and Plastics: UL 94V-O
- J. Dimensions:
  - 1. 24-Port: 1.75" x 19" x 4.82"
  - 2. 48-port: 3.5" x 19" x 4.85"
- K. Performance Compliance:
  - 1. ANSI/TIA/EIA-568-C.2 up to 250 MHz
  - 2. IEEE 802.3ab, 1000BaseT
  - 3. NRTL (ETL) Verified Category 6 component performance
- L. Compliance:
  - 1. RoHS
  - 2. UL Listed

2.35 CATEGORY 6 RATED COPPER PATCH PANELS, FLAT

- A. Design Basis Product: Leviton eXtreme CAT 6+ Patch Panels, or approved equal
- B. For termination of Security Network and Facility Network Category 6 cables in telecommunications spaces.
- C. Panel Configuration: Flat
- D. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed
- E. Contact Material: Copper based alloy plated with 50 micro-inches of gold over 100 micro-inches of nickel
- F. Connection Type: 110 Style, insulation displacement contacts
- G. Connector Configuration: Printed circuit board modules
- H. Panel Material: 16 gauge steel, black powder coat
- I. Printed Circuit Board and Plastics: UL 94V-O
- J. Dimensions:
  - 1. 24-Port: 1.75" x 19" x 1.48"
  - 2. 48-port: 3.5" x 19" x 1.48"
- K. Performance Compliance:
  - 1. ANSI/TIA/EIA-568-C.2 up to 250 MHz
  - 2. IEEE 802.3ab, 1000BaseT
  - 3. NRTL (ETL) Verified Category 6 component performance

- L. Compliance:
  - 1. RoHS
  - 2. UL Listed

2.36 CATEGORY 5E RATED COPPER PATCH PANELS

- A. Design Basis Product: Leviton Voice Grade Patch Panels, or approved equal
- B. For termination of telephone backbone telecommunications spaces
- C. Panel Configuration: Flat
- D. Contact Configuration: 8 position, 8 contact (8p8c / RJ-45), non-keyed
- E. Contact Material: Copper based alloy plated with 50 micro-inches of gold over 100 micro-inches of nickel
- F. Connection Type: 110 Style, insulation displacement contacts
- G. Connector Configuration: Printed circuit board modules
- H. Panel Material: 16 gauge steel, black powder coat
- I. Printed Circuit Board and Plastics: UL 94V-O
- J. Dimensions:
  - 1. 24-Port: 1.75" x 19" x 1.48"
  - 2. 48-port: 3.5" x 19" x 1.48"
- K. Performance Compliance:
  - 1. ANSI/TIA/EIA-568-E
  - 2. IEEE 802.3, 10BaseT
  - 3. NRTL (ETL) Verified Category 5e component performance
- L. Compliance:
  - 1. RoHS
  - 2. UL Listed

2.37 PRIMARY PROTECTORS - DATA GRADE

- A. Design Basis Manufacturer: ITW/Linx Category 6 Building Entrance Surge Protector, or approved equal.
- B. Wall mount 4-pair building entrance protector.
- C. 110-style input connection.
- D. 110-style output connection.
- E. Solid state protectors
- F. Clamping Level: 16V
- G. Response Time: 1-5 nanoseconds

- H. Capacitance: < 5 pF
- I. Dimensions: 4.25" x 4.25" x 1.5"
- J. Compliance: UL 497 Listed for Primary Protection

## 2.38 OPTICAL FIBER CORDS

- A. Design Basis Product: Corning Cable Systems – Fiber Cable Assemblies, or approved equal
- B. Contractor shall provide single fiber cable assemblies for connection and patching of single channel video system equipment and other equipment as indicated.
- C. Contractor shall provide two fiber cable assemblies for connection and patching of telecommunications equipment, servers, network switch uplinks, audio/video equipment and other equipment as indicated.
- D. Single-mode fibers and connectors shall meet or exceed the requirements specified herein.
- E. Multimode fibers and connectors shall meet or exceed the requirements specified herein.
- F. Contractor shall coordinate exact requirements for equipment cords and work area cords with the End Users prior to ordering products.
- G. Contractor shall coordinate exact lengths for patch cords, equipment cords and work area cords with End Users prior to ordering products.
- H. Single Fiber Cable Assemblies
  - 1. Single fiber cable
  - 2. Single-mode: Yellow cable jacket
  - 3. Multimode: Aqua cable jacket
  - 4. LC to LC connectors
  - 5. LC to other connectors as required by terminal equipment
- I. Two Fiber Cable Assemblies
  - 1. Two fiber cable
  - 2. Single-mode: Yellow cable jacket
  - 3. Multimode: Aqua cable jacket
  - 4. Duplex LC to duplex LC connectors
  - 5. Duplex LC to other connectors as required by terminal equipment
- J. Patch Cords
  - 1. Cord Length: 1 meter, 3 meter, 5 meter, 7 meter cable assemblies as required and as coordinated with End Users
  - 2. Quantity:
    - a. Provide one patch cord for each fiber equipment outlet and fiber work area outlet provided as part of this project.
    - b. Provide one-hundred (100) 3 meter patch cords for connecting to servers, network equipment and other equipment.

K. Equipment Cords

1. Cord Length: 1 meter and 3 meter cable assemblies as required and as coordinated with End Users.
2. Quantity: One equipment cord for each fiber equipment outlet provided as part of this project.

L. Work Area Cords

1. Cord Length: 1 meter and 3 meter cable assemblies as required and as coordinated with End Users.
2. Quantity: One work area cord for each fiber work area outlet provided as part of this project.

2.39 CATEGORY 6A RATED COPPER CORDS

- A. Design Basis Product: Leviton eXtreme Category 6A Patch Cords, or approved equal
- B. Contractor shall provide Category 6A patch cords and work area cords for each Category 6A outlet provided as part of this project.
- C. Contractor shall coordinate exact requirements for equipment cords and work area cords with the End Users prior to ordering products.
- D. Contractor shall coordinate exact lengths for patch cords, equipment cords and work area cords with End Users prior to ordering products.
- E. Contractor shall coordinate colors of cords with End Users prior to ordering products.
- F. Copper cords shall meet or exceed the requirements for copper cable systems specified herein.
- G. Conductors: 26 AWG stranded copper
- H. Connector: 8P8C male plug
- I. Snag-less connector or snag-less boot
- J. Patch Cords:
  1. Cord Length: 3 foot, 5 foot, 7 foot, 10 foot, 15 foot and 20 foot cable assemblies as required and as coordinated with End Users
  2. Quantity:
    - a. Provide one patch cord for each Category 6A work area outlet jack provided as part of this project.
    - b. Provide eighty (80) 10 foot patch cords for connecting to servers, network equipment and other equipment.
- K. Work Area Cords
  1. Cord Length: 15 foot and 20 foot cable assemblies as coordinated with End Users.
  2. Quantity: One work area cord for each Category 6A work area outlet provided as part of this project.

2.40 CATEGORY 6 RATED COPPER CORDS

- A. Design Basis Product: Leviton eXtreme Category 6+ Patch Cords, or approved equal

- B. Contractor shall provide Category 6 patch cords, equipment cords and work area cords for each Category 6 outlet provided as part of this project.
- C. Contractor shall coordinate exact requirements for equipment cords and work area cords with the End Users prior to ordering products.
- D. Contractor shall coordinate exact lengths for patch cords, equipment cords and work area cords with End Users prior to ordering products.
- E. Contractor shall coordinate colors of cords with End Users prior to ordering products.
- F. Copper cords shall meet or exceed the respective requirements for copper cable systems as specified herein.
- G. Conductors: 24 AWG stranded copper
- H. Connector: 8P8C male plug
  - 1. Snag-less connector or snag-less boot
- I. Patch Cords:
  - 1. Cord Length: 3 foot, 5 foot, 7 foot, 10 foot, 15 foot and 20 foot cable assemblies as required and as coordinated with End Users.
  - 2. Quantity: Provide one patch cord for each Category 6 work area outlet jack and equipment outlet jack provided as part of this project.
- J. Equipment Cords
  - 1. Cord Length: 3 foot and 10 foot cable assemblies as required and as coordinated with equipment to be installed by this Contractor or other trades.
  - 2. Quantity: One equipment cord for each Category 6 equipment outlet jack provided as part of this project.
- K. Work Area Cords
  - 1. Cord Length: 15 foot and 20 foot cable assemblies as coordinated with End Users.
  - 2. Quantity: One work area cord for each Category 6 work area outlet jack provided as part of this project.

## PART 3 - PART 3 – EXECUTION

### 3.1 INSTALLATION - GENERAL

- A. All products and materials shall be installed in accordance with the Manufacturer's printed instructions and as otherwise recommended by the Manufacturer.
- B. All work shall be installed as shown on the drawings and as specified herein unless otherwise approved by the Professional.

### 3.2 BACKBONE CABLE

- A. Cables shall be installed using pulling and placement methods approved by the manufacturer.
- B. Cable maximum pulling tension and minimum installation bend radius shall not be exceeded during installation.

- C. Cables shall be placed and supported so that the minimum operational bend radius and maximum long-term cable tension are not exceeded.
- D. Install backbone cables using break-away swivels and tension meter or dynamometer when pulling cables with a winch.
- E. Use only cable pulling lubricants approved by the cable Manufacturer. Cable lubricants shall be specifically approved by the cable manufacturer for each type of cable installed.
- F. Thoroughly clean the interior of in slab, slab-on grade and underground conduits with duct swabs prior to the installation of cables.
- G. Mandrel test all underground conduits 2 inches and larger with flexible duct mandrels prior to the installation of cables.
- H. Support all cables to the wall or vertical cable ladder at minimum 3 foot intervals (per Motorola R56) in vertical runs.
- I. Do not bundle or tie cables in cable trays.
- J. Install backbone cables separate from horizontal distribution cables in cable trays and conduits.
- K. Install backbone cables separate from other low-voltage systems cables in cable trays and conduits.
- L. Bundle backbone cables separate from other low-voltage systems cables in overhead or vertical cable ladders.
- M. Dress cables and bundle on overhead cable ladder, through the vertical managers and to the rear of termination patch panels and fiber enclosures.
- N. Bundle cables using ½" wide hook and loop (Velcro) cable fasteners.
- O. Provide a minimum of 10 feet of cable slack for each backbone cable.
  - 1. In telecommunications rooms, cable slack shall be dressed to the overhead cable ladder above the termination rack.
  - 2. In the main equipment room, cable slack shall be dressed inside the termination cabinet.
- P. Label each backbone cable at both ends of the cable and at each pull box or hand-hole location in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.
- Q. Any cable damaged or during installation shall be removed and replaced at no additional cost to the End Users or Department.
- R. Any cable that exceeds minimum bend radius or maximum pulling tension during installation shall be removed and replaced at no additional cost to the End Users or Department.

### 3.3 HORIZONTAL DISTRIBUTION CABLE

- A. Cables shall be installed using pulling and placement methods approved by the manufacturer.
- B. Cable maximum pulling tension and minimum installation bend radius shall not be exceeded during installation.
- C. Cables shall be placed and supported so that the minimum operational bend radius and maximum long-term cable tension are not exceeded.
- D. Use only cable pulling lubricants approved by the cable Manufacturer. Cable lubricants shall be specifically approved by the cable manufacturer for each type of cable installed.

- E. Support all cables to the wall or vertical cable ladder at minimum 5 foot intervals in vertical runs.
- F. Do not bundle or tie cables in cable trays.
- G. Bundle cables to J-hooks using ½" hook and loop type (Velcro) fasteners. Bundle and secure cables in J-hooks only as required to maintain a neat cable dress. Do not bundle cables between J-hooks.
- H. Install a maximum of 24 UTP cables per bundle.
- I. Install horizontal distribution cables separate from backbone cables in cable trays and conduits.
- J. Install horizontal distribution cables separate from other low-voltage systems cables in cable trays and conduits.
- K. Bundle backbone cables separate from other low-voltage systems cables in overhead or vertical cable ladders.
- L. Dress cables and bundle on overhead cable ladder, through the vertical managers and to the rear of termination patch panels and fiber enclosures.
- M. Provide a minimum of 10 feet of cable slack on each cable at the outlet end. Coil and secure the cable slack at the entrance of the conduit feeding the outlet.
- N. Provide a minimum of 20 feet of cable slack on each cable feeding wireless access point outlets. Coil and secure the cable slack at the wireless access point outlet mounting bracket.
- O. Provide a minimum of 10 feet of cable slack on each cable at the telecommunications space termination rack or cabinet.
  - 1. Dress and secure the cable slack on the cable ladder above the termination racks.
  - 2. Dress and secure the cable slack in the rear of the cable termination cabinets.
  - 3. If insufficient room exists to store the cable slack in the termination cabinets, dress and store the cable below the raised floor. Where no raised floor exists, dress the cable on the cable ladder above the termination cabinets.
- P. Install and dress cables under raised floors to minimize the bulk of the cables to avoid blocking airflow in the in the raised floor space.
- Q. Bundle cables using ½" wide hook and loop (Velcro) cable fasteners.
- R. Maintain cable jacket to as close as possible to the termination patch panel connector blocks.
- S. Maintain pair twists to within ½" of the termination connector blocks.
- T. Label each horizontal distribution cable at both ends of the cable in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.
- U. Any cable damaged or during installation shall be removed and replaced at no additional cost to the End Users.
- V. Any cable that exceeds minimum bend radius or maximum pulling tension during installation shall be removed and replaced at no additional cost to the End Users or Department.

### 3.4 FIBER CONNECTORS

- A. In telecommunications spaces, terminate 900 micron buffered fibers directly in fiber termination enclosures.

- B. Provide a minimum of two meters of fiber slack for each fiber coiled in the back of the fiber termination enclosure.
- C. In telecommunications outlets, provide cable furcation kits to build up the 900 micron buffered fiber units to a minimum of 2mm before installing connectors.
- D. Provide a minimum of one meter of fiber slack for each fiber coiled inside each outlet. Where one meter of fiber slack cannot be stored inside the outlet, pull the slack up and store with the cable slack at the top of the conduit.
- E. Clean and inspect each connector under a minimum 100 power microscope prior to connecting fiber to the adapter in termination enclosures and outlets. Replace all connectors showing defects upon inspection.
- F. Maintain all dust caps on all connectors and adapters unless the specific fiber is under test.

### 3.5 CATEGORY RATED COPPER CONNECTORS

- A. Provide a minimum of 12" of slack on each category rated cable in each outlet.
- B. Where the outlet termination space is not sufficient to house the 12" of slack, pull the slack up and store with the cable slack at the top of the conduit.
- C. Maintain cable jacket to as close as possible to the termination connector block.
- D. Maintain pair twists to within ½" of the termination connector block.

### 3.6 WORK AREA OUTLETS

- A. Coordinate exact location of each work area outlet, floor box and poke-through with the furniture plans prior to rough-in.
- B. Coordinate exact location of each work area outlet, floor box and poke-through with the End Users prior to rough-in.
- C. Provide a minimum 1-1/4" conduit from each wall mounted work area outlet box to the nearest cable tray, pull box, or to above an accessible ceiling.
- D. Dress cables into each outlet box to maintain minimum bend radius.
- E. Label each connector of each outlet in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.

### 3.7 EQUIPMENT OUTLETS

- A. Coordinate exact location of each equipment outlet with the equipment to be installed by this Contractor or as the work of other trades.
- B. Where possible, equipment outlets shall be installed in the equipment enclosure adjacent to the equipment network or telecommunications connector.
- C. Equipment outlets shall be installed in the same enclosure as the equipment network or telecommunications connector unless there is insufficient space, or so doing would void the equipment warranty.
- D. Mount equipment outlets inside the equipment enclosure or NEMA 1 enclosure with permanent double sided transfer adhesive or screws.

- E. Where installing the equipment outlet in the equipment enclosure is not possible, provide a 6" x 6" x 4" NEMA 1 screw cover box within six inches of the equipment enclosure. Connect the equipment enclosure to the NEMA 1 box with a minimum 1" conduit.
- F. Provide a minimum 1" conduit from the equipment enclosure or the NEMA 1 enclosure to the nearest cable tray, pull box, or to above an accessible ceiling.
- G. Provide an equipment cord of sufficient length to connect from the equipment outlet to the equipment network or telecommunications connection.
- H. Label each connector of each outlet in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.

### 3.8 WIRELESS ACCESS POINT OUTLETS

- A. Provide an outlet box (4-11/16" x 1-11/16" or 5"x5") with a single gang device ring above the accessible ceiling at each wireless access point location. Provide a 3/4" or 1" close nipple with two grommets (or gland nut connector) in one of the knockouts in the outlet box.
- B. Mount the outlet box with an L-bracket and beam clamp (or other demountable attachment) to the building structure to allow the outlet box to be moved by the End Users when installing the wireless access point. Refer to cable slack requirements for wireless access point outlets specified herein.
- C. Secure the cable inside the outlet box with a hook and loop (Velcro) fastener.
- D. Dress cables into each outlet box to maintain minimum bend radius.
- E. Mount the wireless outlet port outlet connector to a single gang stainless steel faceplate attached to the outlet box.
- F. Label each connector of each outlet in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.
- G. Provide an engraved laminated plastic label applied to the ceiling grid directly below the consolidation point.
  - 1. The engraved laminated plastic label shall be white with black 1/4" high letters.
  - 2. The label shall have the same identification number as the wireless access point outlet above the accessible ceiling.
  - 3. Apply the label to the ceiling grid with removable double sided tape.
  - 4. Furnish one roll of removable double sided tape to the End Users for labeling wireless access point outlets that are relocated by the End Users.

### 3.9 CONSOLIDATION POINTS

- A. Install consolidation points above an accessible ceiling located centrally to the floor boxes it serves.
- B. Install consolidation points to provide full access to the termination blocks.
- C. Attach consolidation points to the building structure with hardware appropriate to the attachment surface/material.
- D. Consolidation point enclosures and termination blocks may be installed in a vertical or horizontal orientation as dictated by the space above the accessible ceiling.
- E. Provide a minimum 1-1/4" conduit from each slab on grade floor box to the consolidation point.

- F. Provide close nipples through the side of the consolidation point for the plenum cable to exit.
- G. Provide one 1" close nipple for each outlet served from the consolidation point.
- H. Provide grommets on both ends of each close nipple.
- I. Dress and terminate outside plant rated cables to the termination block base.
- J. Dress and terminate plenum rated cables to the connecting block contacts.
- K. Bundle and attach cables to the enclosure backboard with ½" hook and loop (Velcro) fasteners.
- L. Label the consolidation point and each cable in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.
- M. Provide an engraved laminated plastic label applied to the ceiling grid directly below the consolidation point.
  - 1. The engraved laminated plastic label shall be white with black ¼" high letters.
  - 2. Apply the label to the ceiling grid with permanent double sided transfer adhesive, or white #4 metal screws.

### 3.10 FIBER TERMINATION ENCLOSURES

- A. Mount fiber termination enclosures to the rack/cabinet mounting rails with a minimum of four machine screws.
- B. Secure fiber cable jackets and fiber cable strength members in the fiber termination enclosures as recommended by the manufacturer.
- C. Provide blank connector plates in all unused spaces.
- D. Maintain all dust caps on all connectors and adapters unless the specific fiber is under test.
- E. Label each termination enclosure and each port of each termination enclosure in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.270500

### 3.11 PATCH PANELS

- A. Mount patch panel to the rack/cabinet mounting rails with a minimum of four machine screws.
- B. Dress cables from both sides of the patch panel to minimize cable bulk in the termination area.
- C. Provide cable stand-off brackets for dressing cables as required to maintain an orderly termination area.
- D. Secure and bundle cables at the rear of patch panels with ½" hook and loop type (Velcro) fasteners.
- E. Label each patch panel in accordance with the approved labeling scheme. Refer to Section 270500, Common Work Results - Communications for labeling requirements.

### 3.12 TERMINATION BLOCKS

- A. Mount termination block legs to mounting surface with a minimum of four screws.
- B. Dress backbone cables under the termination base and terminate to the termination block base.

- C. Dress horizontal distribution cables (for interconnects) and cross-connect wire (for cross-connects) and terminate to the front of the connecting blocks.
- D. Provide distribution posts and distribution rings as required to neatly organize and dress cross-connect wires in the cross-connect field.

### 3.13 PRIMARY PROTECTORS

- A. Provide primary protectors on each end of all copper cables installed outside of the building footprint.
- B. Wall mount all primary protectors as close as practicable to the cable entrance.
- C. Dress cables to the primary protector wiring blocks as specified for routing of cables for termination blocks.
- D. Bond all cable shields (when applicable) to the building entrance protector with a minimum #6 AWG ground wire.
- E. Bond the building entrance protector to the telecom room ground bus bar with a minimum #2 AWG ground wire.
- F. Install protector modules on all wire pairs installed as part of this project.
- G. Furnish spare modules to the End Users for future use.

### 3.14 CROSS-CONNECTS

- A. Provide cross-connect wire as required to connect telephone circuits from the telephone service provider's demarcation point to the backbone termination blocks.
- B. Provide all cross-connects required to provide telephone circuits to emergency telephones, elevator telephones, fire alarm control panels, security control panels and other equipment requiring hard-wired connections. Coordinate exact requirements with the End Users and the equipment installers.
- C. Provide a minimum one-inch drip loop in each cross-connect wire for wire tracing. dress the drip loops neatly to the side of each termination block.

### 3.15 PATCH CORDS

- A. Contractor shall install all patch cords between patch panels as coordinated with the Owner.
- B. Contractor shall install all patch cords between patch panels and rack mount equipment as coordinated with the Owner.
- C. Install patch cords along shortest path between patch panels and equipment.
- D. Neatly store all patch cords slack in the vertical management hardware adjacent to the source and destination patch panel and equipment ports. Leave relatively equal amounts of slack at each end of the patch cord.
- E. All patch cords shall be installed with a service loop stored in the vertical management hardware to simplify patch cord tracing.
- F. Do not bundle patch cords in the vertical and horizontal cable management hardware. Cables shall be secured in the vertical cable management channels with retaining clips or by routing over cable spools.

- G. Install patch cords on cable ladder or in cable tray only as required to transition between rows of cabinets and racks. Bundle patch cords installed on cable ladder or in cable tray separately from horizontal distribution cables and backbone cables.
- H. Patch cords between cabinets and racks in the same row shall be installed through the horizontal and vertical cable management hardware.

### 3.16 WORK AREA CORDS

- A. Contractor shall furnish all work area cords in their original packaging to the End Users for installation by the End Users.

### 3.17 EQUIPMENT CORDS

- A. Contractor shall furnish equipment cords for connection of wireless access points in their original packaging to the End Users for installation by the End Users.
- B. Contractor shall install equipment cords for connection of installed equipment, connect equipment cords between equipment outlets and equipment, coordinate connection to equipment with Contractor responsible for equipment installation. Furnish equipment cord to equipment installer if the equipment is not ready for connection, or the equipment installer must make the connection.

### 3.18 TESTING

- A. Testing shall be as specified in Section 270500 Common Work Results – Communications.

### 3.19 AS-BUILT RECORD DOCUMENTS

- A. As-Built Record Documents shall be assembled and submitted as required by the Division 1 Requirements, Section 270500 Common Work Results – Communications and as described herein.

END OF SECTION

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## SECTION 271116 - EQUIPMENT ROOMS AND FITTINGS

### 1.1 STIPULATIONS

- A. The specification sections "General Conditions of Contract," "Special Conditions," and "Division 1 – General Requirements" form a part of this section by this reference thereto, and shall have the same force and effect as if printed herewith in full.

### 1.2 SUMMARY

- A. The Work of this Section includes all labor, materials, and equipment to provide the communications system components stated below:
  - 1. Cabinets, racks, frames and enclosures
  - 2. Cable-management hardware

### 1.3 RELATED SECTIONS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Section 260500 – Common Work Results – Electrical
- C. Section 260526 – Grounding and Bonding
- D. Section 262533 – Raceways and Boxes
- E. Section 270500 – Common Work Results – Communications
- F. Section 270526 – Grounding and Bonding for Communications Systems
- G. Section 271000 – Structured Cable System

### 1.4 CODES, STANDARDS AND DOCUMENTS

- A. Contractor shall comply with the most recent edition of the referenced Codes and Standards, unless otherwise noted.

1. Motorola R56® – Standards and Guidelines for Communications Sites
2. Harris Site Grounding and Lighting Protection Guidelines
3. National Fire Protection Association (NFPA) 70 – National Electrical Code (NEC)
4. American National Standards Institute/Telecommunications Industry Association (ANSI/TIA)-568-E – Series - Commercial Building Cabling Standards
5. TIA-569-E – Commercial Building Standard for Telecommunications Pathways and Spaces
6. ANSI/TIA-606-C – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
7. ANSI/TIA-607-D – Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises
8. ANSI/TIA-942-B – Telecommunications Infrastructure Standard for Data Centers
9. Building Industries Consulting Services, International (BICSI) Telecommunications Distribution Methods Manual (TDMM), latest edition
10. ANSI/BICSI-002-2019 – Data Center Design and Implementation Best Practices

#### 1.5 SUBMITTALS

- A. All submittals shall be submitted for review and approval in accordance with the Division 1 Requirements.
- B. Contractors shall submit data for each product specified in this Section.
- C. Contractor shall submit qualifications for the Contractor's supervisor/foreman responsible for the installation of the structured cabling and grounding systems.

#### 1.6 COORDINATION

- A. Contractor shall coordinate with the General Contractor the exact location of the cabinets, racks and enclosures relative to the system layout in the main equipment room.
- B. Contractor shall coordinate the layout of telecommunications equipment, hardware, and raceways, as well as the work of other trades, in the telecommunications rooms prior to rough-in.

#### 1.7 QUALITY ASSURANCE

- A. The Contractor shall adhere to the quality assurance (QA) requirements as defined in the Division 1 Requirements, as follows:
  1. All products shall be Listed for the specific application intended as part of this Work.
  2. All products shall be Listed and Labeled by Underwriters Laboratories (UL) or another nationally recognized test laboratory (NRTL).
  3. At a minimum, the Contractor's supervisor/foreman responsible for the installation of the Work of this Section, shall be trained by the manufacturer for installation of the products installed as part of the Work.

## 1.8 DELIVERY, STORAGE, AND HANDLING

- A. All products shall be delivered to the site in the original manufacturer's packaging, distributor's packaging or other packaging suitable for protection of the materials.
- B. All products stored offsite and onsite shall be maintained in a manner to protect the materials from weather, corrosion, or damage.
- C. All products shall be stored in a secure location under the direct control of the Contractor.
- D. All products shall be handled as recommended by the Manufacturer.
- E. Any products exhibiting evidence of damage, corrosion, or defect shall be removed from site and replaced at no additional cost to Owner.

## PART 1 - DESIGN BASIS MANUFACTURERS

- A. Products from the following manufacturers generally conform to the specific design basis for the Work. Subject to product compliance with the requirements of the Construction Documents, acceptable manufacturers include, but are not limited to:
  - 1. American Power Conversion (APC)
  - 2. Chatsworth Products Incorporated (CPI)
  - 3. Cooper/B-Line
  - 4. Middle Atlantic Products
  - 5. Great Lakes Case and Cabinet
- B. All products provided as part of this Work shall be Listed for their intended use by a NRTL.
- C. All products shall be Listed for their specific types, sizes, and combinations of conductors and connected items.

## PART 2 - OVERHEAD CABLE RUNWAY

- A. Design basis product: Chatsworth Products, Inc., UL Listed cable runway and accessories, or approved equal.
- B. Contractor shall provide cable runway mounted six inches above racks in telecommunications rooms, as indicated on the Drawings and as specified herein.

- C. Dimensions: 18-inches wide x 9 feet 8-1/2-inches long sections.
- D. Material: Steel.
- E. Construction: Tube steel rungs welded to tube steel side rails.
- F. Side rail dimensions: 1-1/2 inch x 3/8 inch x 0.65 inch tube.
- G. Rung dimensions: 1/2 inch x 1 inch x 0.65 inch tube.
- H. Rung spacing: 9 inches.
- I. Color: Black chem film.
- J. UL Classified for use as an equipment grounding conductor.
- K. Contractor shall provide all mounting, bonding, and grounding hardware, including, but not limited to:
  - 1. Rack-top mounting kits
  - 2. "Waterfall" cable entries into racks/cabinets
  - 3. Runway mounting feet
  - 4. Runway mounting angles
  - 5. Runway splice kits
  - 6. Vertical bonding bus bars

### PART 3 - EQUIPMENT CABINETS, FLOOR MOUNT

- A. Design basis product: Middle Atlantic MRK Series enclosure, or approved equal.
- B. Cabinet dimensions (min.): 84 inches high x 24 inches wide x 42 inches deep, nominal.
- C. Frame material: 1/8-inch thick structural steel.
- D. Mounting rails:
  - 1. Two sets of mounting rails per cabinet, front and rear, fully adjustable front to rear.
  - 2. Additional mid-rack vertical mounting rails for center hung equipment.
  - 3. Full height of useable space
  - 4. Mounting holes: #10/32 tapped
  - 5. Electronic Industries Alliance (EIA)-310-D universal mounting hole spacing: 5/8 inch, 5/8 inch, 1/2 inch

6. Material: Tapped rail, 11-gauge steel
- E. Top panel:
  1. Solid with knockouts for cable pathways
  2. Material: 18-gauge steel
  3. Color: Black powder or epoxy coat
- F. Side panels:
  1. Solid
  2. Material: 20-gauge steel
  3. Color: Black powder or epoxy coat
- G. Front door:
  1. Full-width front door
  2. Locking handle
  3. Perforated
  4. Perforated area: 60 percent
  5. Material: 18-gauge steel
  6. Color: Black powder or epoxy coat
- H. Rear door:
  1. Half-width split rear doors
  2. Locking handle
  3. Perforated
  4. Perforated area: 60 percent
  5. Material: 18-gauge steel
  6. Color: Black powder or epoxy coat
- I. Provide two (2) vertical patch cord management units, with front and rear channels, from top to bottom of each cabinet/rack.
  1. Use standard of 6" on server cabinets (or at end of rows) and 10" on cabling cabinets (or between cabinets mid-row).
  2. Color: Black powder or epoxy coat

- J. Provide each cabinet with two (2) vertical power strip.
  - 1. Minimum of 12 National Electrical Manufacturers (NEMA) 5-20R receptacles
  - 2. Plug strips shall be monitored and controlled by BAS or DCIM system.
  - 3. Receptacles spaced for installation of wall-mount transformers.
  - 4. Power strips shall be connected to separate UPS circuits using a twist-lock plug.
- K. Provide a cabinet Rack Bonding Bar (RBB) in each cabinet.
  - 1. Material: 110 alloy copper
  - 2. Minimum Dimensions: 3/16 inches thick x 72 inches high x 3/4 inch wide
  - 3. Use two-hole (preferred) or one-hole (acceptable) grounding lugs on all bonding connections.
  - 4. Lug mounting holes:
    - a. Each shall be 1/4-inch tapped lug holes spaced to maximize equipment bonding conductor quantities.
    - b. Two (2) pairs of SS studs or holes sized to accommodate 5/16-inch SS hardware, on 3/4 or 1-inch centers.
- L. Provide bonding jumpers to bond the cabinet frame, doors, side panels, top, mounting rails, cable management, etc., to ground as a single assembly.
- M. Provide keyed locks on all cabinets.
  - 1. All doors and panels shall be keyed alike
  - 2. Coordinate exact requirements for cabinet keying with the Owner's information technology (IT) department prior to placing orders
- N. Finish: Black powder or epoxy coat.
- O. Accessories:
  - 1. Leveling feet (all cabinets)
  - 2. Rack shelves, fixed, as shown on the Drawings
  - 3. #10-32 mounting screws, 100 pieces

#### PART 4 - EQUIPMENT CABINETS, WALL MOUNT

- A. Design basis product: Middle Atlantic CWR Series cabling wall-mount rack or approved equal.
- B. Three-section wall-mount cabinet.

- C. Solid front door.
- D. Solid center section with louvered/vented side panels.
- E. Solid rear section with knock outs for conduits.
- F. Locking front door and center cabinet section.
- G. Left- or right-hand swing.
- H. Cabinet dimensions: 48 inches high x 24 inches wide x 24 inches deep, nominal.
- I. Material: 16-gauge steel.
- J. Solid front door.
- K. Ventilated sides.
- L. Mounting rails:
  - 1. 11-gauge steel
  - 2. Tapped 12-24 mounting holes
  - 3. Universal EIA-310 spacing
- M. Weight Capacity: 250 pounds.
- N. Provide a cabinet horizontal RBB in each cabinet.
  - 1. Material: 110 alloy copper
  - 2. Dimensions: 3/16 inch thick x 3/4-inch high x 19 inches wide, minimum.
  - 3. Provide isolation mounts for the ground bus
  - 4. Lug mounting holes:
    - a. 1/4-inch tapped lug holes spaced to maximize equipment bonding conductor quantities.
    - b. Two (2) pairs of 5/16-inch diameter holes, on 3/4-inch centers. SS studs or holes sized to accommodate 5/16-inch SS hardware, on 3/4 or 1-inch centers.
    - c. The RBB shall be mounted on insulators to provide separation between dissimilar metals.
- O. Provide each cabinet with two (2) horizontal power strips.
- P. Each power strip shall have a 6-foot cord.
- Q. Minimum of six (6) NEMA 5-20R receptacles per power strip.

- R. Receptacles spaced for installation of wall-mount transformers.
- S. Provide bonding jumpers to bond the cabinet frame, doors, etc. to the grounding system as a single assembly.
- T. Provide keyed locks on all cabinets.
  - 1. All doors and panels shall be keyed alike
- U. Finish: Black powder or epoxy coat.
- V. Accessories: #12-24 mounting screws, 24 pieces minimum.

#### PART 5 - HORIZONTAL CABLE MANAGERS

- A. Design basis product: CPI Universal Horizontal Cable Manager, or approved equal.
- B. Provide 1RU and 2RU horizontal cable managers between patch panels and equipment, as indicated on the drawings.
- C. Single-sided vertical cable management section.
- D. Dimensions:
  - 1. 1RU: 19 inches x 1.75 inches x 21.23 inches
  - 2. 2RU: 19 inches x 3.5 inches x 21.23 inches
- E. 1.75-inch management finger spacing.
- F. Removable 180-degree hinged covers.
- G. Materials: UL 94V-O plastic.
- H. Color: Black.

#### PART 6 - TOP AND BOTTOM JUMPER CABLE MANAGERS

- A. Design basis product: CPI upper and lower jumper trays, or approved equal.
- B. Provide upper and lower jumper trays at the top and bottom of each rack, and as indicated on the drawings.
- C. Dimensions:
  - 1. Upper tray: 19 inches x 4 inches x 6 inches

- 2. Lower tray: 19 inches x 4 inches x 3.5 inches
- D. Material: Aluminum or steel.
- E. Color: Black.

#### PART 7 - BACKBOARDS

- A. Contractor shall provide plywood backboards on all walls of telecommunications rooms, and as otherwise indicated on the drawings.
- B. Material: 8-foot x 4-foot x 3/4-inch, fire-retardant plywood.
- C. Grade: C or better.
- D. Construction: 3-5 layer, alternating grain, laminated.
- E. Contractor shall paint all sides of plywood with white fire-retardant paint prior to installation.
- F. Contractor shall paint the exposed faces of the plywood with one additional coat of white fire-retardant paint after plywood is installed.

#### 3.1 INSTALLATION – GENERAL

- A. All products and materials shall be installed as recommended by the manufacturer.
- B. All work shall be installed as shown on the drawings and as specified herein, unless otherwise approved by the System Designer.
- C. The Contractor shall bond all metal and metallic materials in each space to the telecommunications ground bus bar in the respective telecommunications and equipment rooms.
  - 1. Remove any paint, coatings, or finishes in the areas of grounding and bonding connections as required to make and maintain a ground connection. Apply the proper antioxidant between all metal to metal bonds.
  - 2. Where possible, order equipment with designated grounding connections, masked to avoid any paint, coating, or finish material.

#### 3.2 CABLE RUNWAY

- A. A cable runway shall be installed over all racks and to provide a pathway from the racks to the conduits and conduit sleeves exiting the telecommunications room.

- B. Vertical sections of cable runway shall be installed from the conduit sleeves through the floor up to the overhead cable runway.
- C. Cable runway shall be supported to the top of each rack with a 6-inch stand-off bracket. Coordinate with power, HVAC, fire suppression, and lighting.
- D. The Contractor shall coordinate placement of the cable runway with lighting, sprinkler heads, smoke detectors, access panels, and like equipment and maintenance accesses in each telecommunications room.
- E. The cable ladder shall be attached to walls and floors with mounting feet with 3/8-inch mounting hardware.

### 3.3 EQUIPMENT CABINETS

- A. Equipment racks shall be assembled using all of the hardware provided by the manufacturer.
- B. Equipment racks shall be set and leveled with leveling feet.
- C. The Contractor shall coordinate the quantity and placement of floor access for each cabinet with the floor installer.
- D. All accessories shall be installed in accordance with the manufacturer's installation and assembly instructions.
- E. Vertical cable managers shall be installed at the front and rear, and on both sides, of each cabinet.
- F. The Contractor shall coordinate the placement of the mounting rails with the depth of the equipment, cable management, and equipment to be provided by the Owner. Adjust the mounting rails as required to accommodate cable and cord installation, routing, and management in each cabinet.
- G. The Contractor shall provide knock outs and grommets for cable pathways between cabinets, with separator panels, as coordinated with the Owner.
- H. A cabinet ground bus shall be installed on each equipment rack. Equipment racks served from overhead shall have the vertical RBB.
- I. Each cabinet shall be bonded to the telecommunications ground bus in the telecommunications room with #2 AWG (American wire gauge) green insulated stranded copper wire, minimum, size per Motorola R56 Table 5-3.
- J. All metal and metallic components of each rack/cabinet shall be bonded to form a single grounded assembly for connection to the ground bus and telecommunications room ground.

- K. The Contractor shall turn over all keys to all cabinets to the Owner.
- L. All airflow management equipment and devices shall be installed in coordination with, and in cooperation with, the installation of equipment by the Owner.
- M. The Contractor may, at its option, stage the racks/cabinets at its facility for the purpose of installing and configuring equipment. The Contractor shall assume full responsibility for all furnished materials from the time the Contractor takes possession until the time that the work is accepted by the Owner.

### 3.4 EQUIPMENT RACKS

- A. Equipment racks shall be assembled using all hardware provided by the manufacturer.
- B. The Contractor shall attach each equipment rack to the floor using 3/8-inch hardware, minimum.
- C. The overhead cable ladder shall be attached to the top of each equipment rack with a 6-inch stand-off bracket.
- D. Each rack, shall be bonded to the RBB in the telecommunications room with #6 AWG green insulated stranded copper wire, minimum. See Motorola R56 Table 5-3 for conductor size based on distance.

### 3.5 VERTICAL CABLE-MANAGEMENT HARDWARE

- A. The Contractor shall attach vertical cable-management hardware to cabinets and racks through all mounting holes provided on the hardware.
- B. Cable spools, guides, and brackets shall be installed as required to properly support the installed cables.
- C. The Contractor shall dress and attach installed cables to vertical cable-management hardware with 1/2-inch-wide, hook-and-loop-style fasteners (e.g., Velcro) or other approved material.
- D. Patch cords and equipment cords in the vertical cable managers shall be dressed in a neat and orderly manner.
  - 1. Provide drip loops where appropriate
  - 2. Store cable slack throughout the vertical cable managers to avoid congestion and unmanageable cable bundles
  - 3. Do not tie or secure patch cords in vertical cable managers

- E. Cables and cord slack shall be dressed and stored in vertical cable managers in a manner that allows the covers to be closed without forcing the cover closed or pinching protruding cable/cord.

### 3.6 BACKBOARDS

- A. The Contractor shall attach plywood backboards over gypsum wall board, concrete, or masonry structure with mounting hardware suitable to the mounting surface, without causing cracking or damage to the plywood edges.
- B. Plywood backboards shall be installed corner to corner on specified walls of each telecommunications room.
- C. Plywood backboards shall be installed at the locations shown on the walls of equipment rooms.
- D. Plywood shall be installed starting at 12-inch AFF and extending up to 108-inch AFF.
- E. Plywood may be installed vertically or horizontally.
- F. For installation on gypsum wall board, each full sheet of plywood shall be attached to a minimum of three studs, and at a maximum of 24-inch intervals in the horizontal and vertical directions, and along the edges.
- G. For installation on masonry or concrete walls, each full sheet of plywood shall be attached at a maximum of 24-inch intervals in the horizontal and vertical directions, and along the edges.

END OF SECTION

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## SECTION 281500 - ACCESS CONTROL HARDWARE 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. Card readers, credential cards, and keypads
  - 2. Cables
  - 3. Transformers
- B. Related Requirements:
  - 1. Section 281300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.

#### 1.3 DEFINITIONS

- A. Credential: Data assigned to an entity and used to identify that entity.
- B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- C. 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.
- D. 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.
- E. PC: Personal computer. Applies to the central station, workstations, and file servers.
- F. RAS: Remote access services.
- G. RF: Radio frequency.
- H. ROM: Read-only memory. ROM data are maintained through losses of power.
- I. TCP/IP: Transport control protocol/Internet protocol.

- J. 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.
- K. WMP: Windows media player.
- L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- M. 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. Product Schedules.
- D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

#### 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 Section 017823 "Operation and Maintenance Data," include the following:

1. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on [USB] [cloud] media of the hard-copy submittal.
2. System installation and setup guides with data forms to plan and record options and set-up 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. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
  2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.
  3. .

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
  1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
- B. 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.
- C. 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.
- D. 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 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 environ-

- ments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Outdoor Environment: NEMA 250, NEMA 250, Type 3R enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.

## PART 2 - PRODUCTS

### 2.1 OPERATION

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.

### 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. Comply with NFPA 70, "National Electrical Code."
- C. Comply with SIA DC-01 and SIA DC-03.

### 2.3 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. ABB Low Voltage products; Member of ABB Group.
  2. Alco Advanced Technologies.
  3. Bosch Security Systems, Inc.
  4. GE Security, Inc.
  5. Honeywell Security Products- Americas.
  6. Schneider Electric USA, Inc.
- B. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
- C. 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.
- D. 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. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

- E. Display: Digital visual indicator shall provide visible 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.
- F. 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 in a humidity range of 10 to 90 percent.
- G. Wiegand Swipe Reader: Set up for 33-bit data cards. Comply with SIA AC-01.
- H. Wiegand Key-Insert Reader: Set up for 33-bit data cards.
- I. Bar-Code Reader: Set up for Code 39 <Insert number>.
- J. Insert Readers: Requiring the card to be inserted from the side, powered by the controller.
- K. 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. The card reader shall read proximity cards in a range from direct contact to at least 6 inches from the reader.
- L. 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.
- M. Keypad Display:
  - 1. Keypads shall include a digital visual indicator and shall provide visible 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.
- N. 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.
- O. Keypad Power:
1. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
- P. Keypad Mounting Method:
1. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
- Q. Keypad Duress Codes:
1. Keypads shall provide a means for users to indicate a duress situation by entering a special code.
- R. 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: Set up for 33-bit data cards to generate a unique card identification code. Comply with SIA AC-01.
- S. Communication Protocol: Compatible with local processor.
- T. 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.
- U. 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.
- V. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
- W. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.

X. 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. Furnish equipment for on-site assembly and lamination of credential cards.
  - a. Indoors, controlled environment.
  - b. Outdoors.
4. Display: Digital visual indicator shall provide visible status indications and user prompts. Indicate power on or off and whether user passage requests have been accepted or rejected.

2.4 PUSH-BUTTON SWITCHES

- A. Push-Button Switches: Momentary-contact back-lighted push buttons with stainless-steel switch enclosures.
- B. 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.
- C. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
- D. Enclosures shall additionally be suitable for installation in the following locations:
  1. Indoors, controlled environment.
  2. Outdoors.
- E. Power: Push-button switches shall be powered from their associated controller, using dc control.

2.5 CABLES

- A. General Cable Requirements: Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems" and as recommended by system manufacturer for integration requirement.
- B. PVC-Jacketed, TIA 232-F.
  1. Three, No. 22 AWG, stranded (7x30) tinned copper conductors.
  2. Polypropylene insulation.
  3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
  4. PVC jacket.
  5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
  6. Flame Resistance: Comply with UL 1581.

C. Plenum-Rated TIA 232-F Cables:

1. Three, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PE insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. Fluorinated ethylene propylene jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

D. PVC-Jacketed, TIA 485-A Cables:

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. NFPA 70 Type: Type CM.
6. Flame Resistance: Comply with UL 1581.

E. Plenum-Rated TIA 485-A Cables:

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. NFPA 70 Type: Type CMP
6. 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, 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.

H. 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.

I. LAN Cabling:

1. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

2.6 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

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 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Install cables and wiring according to requirements in Section 270513 "Conductors and Cables for Communications Systems."

- 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. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.
- E. 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.
- F. 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-D, "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. between terminations.
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. between terminations.
- 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., and install No. 20 AWG wire if maximum distance is 500 ft..
  - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
  - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft. between terminations.
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. between terminations.

### 3.5 GROUNDING

- A. Comply with Section 270526 "Grounding and Bonding for Communications 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. 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 Section 270553 "Identification for Communications Systems" and with TIA 606-B.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alpha-numeric 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 tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.

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 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 281500

## **SECTION 282300 – VIDEO SURVEILLANCE SYSTEM**

### **PART 1 – GENERAL**

#### **1.1 DESCRIPTION**

- A. Provide and install a complete and turn-key Video Surveillance System, hereinafter referred to as the VSS as specified in this section.
- B. The VSS shall interface with the Access Control System, as part of an integrated security system.
  - 1. The VSS will be monitored (24x7) from a workstation on the site, through a computer-based application running an integrated Security Management System (SMS) application.
  - 2. The VSS shall receive video images for live monitoring, long term storage, playback, and export from the SMS control station.
  - 3. The VSS shall be capable of establishing multiple zones using specific cameras, for facility monitoring using video motion detection feature. Once motion is detected, the VSS shall increase the recording frame rate, and bring up that image at the control station for review.
- C. This Section includes the following:
  - 1. VSS is a complete turnkey system with: Internet Protocol (IP) based core equipment including control and storage, internal IP camera, external IP cameras, PoE switches, power supplies, cabling, and connectivity.
  - 2. Video control system and application for programming, control, storage retrieval.
  - 3. Responsibility for integrating electronic and electrical systems and equipment is specified in the following Sections, with Work specified in this Section:
    - a. Division 26 Section "COMMON WORK RESULTS - ELECTRICAL"
    - a. Division 27 Section "COMMON WORK RESULTS - COMMUNICATIONS"
    - b. Division 28 Section "ACCESS CONTROL SYSTEM".
- D. Video signal format shall be High Definition (HD), high resolution 1080p, color, with low light operation in monochrome or black and white (B/W).
- E. 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.

#### **1.2 RELATED SECTIONS**

- A. Division 01 - GENERAL REQUIREMENTS.
- B. Section 078413 – PENETRATION FIRE STOPPING.
- C. Section 262726 - WIRING DEVICES
- D. Section 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- E. Section 281500 - ACCESS CONTROL HARDWARE DEVICES

### 1.3 QUALITY ASSURANCE

- A. The Contractor shall be responsible for providing, installing, configuration and training of the VSS as described.
- B. The security system shall be installed and tested to ensure all components are fully compatible as a system and can be integrated with all associated security sub-systems.

### 1.4 SUBMITTALS

- A. Submit below items in conjunction with Division 1, SUBMITTALS.
- B. Provide a shop drawing and as-built design package in both electronic format and on paper, per the established project schedule.
- C. Provide complete Bill of Materials for all components to be used, and Manufacturer's cut sheet for these products.
- D. Show drawings shall include, but not be limited to:
  - 1. Index Sheet with drawing numbers, drawing names, general notes, symbol legend, and definitions.
  - 2. Drawing sheets shall include device identification and location, conduit runs and sizes, and pull boxes.
  - 3. Riser diagram, or point-to-point diagram:
    - a. Interface for each security sub-system, IT network interface, and fire alarm interface.
    - b. Include the quantity, size, cable types, interface types, and identification number of connection types.
  - 4. Provide manufacturer cut-sheets for all security system products.
  - 5. Submit for approval, at least 30 days prior to commencement of formal testing, a Security System Acceptance Test Plan (ATP). Include procedures for operational testing of each component and security sub-system, to include performance of an integrated system testing.
- E. No work shall begin until the shop drawings are approved.
- F. As-built drawing package will be prepared during the project and provided to the Owner at the project close.
- G. As-built drawings shall be reviewed by the Owner representative to ensure all work has been clearly defined and completed. All reviews shall be conducted in accordance with the project schedule. There shall be four (4) stages to the review process:
  - 1. 35 percent
  - 2. 65 percent
  - 3. 90 percent
  - 4. 100 percent
- H. As-built documentation shall include a schedule for all security sub-system including the following information:
  - a. Device ID.
  - b. Device model numbers.
  - c. Device Location (e.g. site, building, floor, room number, location, and description).

- d. Mounting type (e.g. flush, wall, surface, etc.).
- e. Power supply or circuit breaker and power panel number.
- f. In addition, for the IDS, provide the sensor ID, sensor type and housing model number.
- I. As-built drawings shall include mounting details and elevations for all devices.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below (including amendments, addenda, revisions, supplement, and errata) form a part of this specification to the extent referenced. This VSS and all associated security sub-systems shall be compliant with these publications.
- B. American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA):
  - 330-09 .....Electrical Performance Standards for CCTV Cameras
  - 375A-76.....Electrical Performance Standards for CCTV Monitors
- C. Institute of Electrical and Electronics Engineers (IEEE):
  - C62.41-02 .....IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
  - 802.3af-08 .....Power over Ethernet Standard
- D. Federal Communications Commission (FCC):
- E. (47 CFR 15) Part 15.....Limitations on the Use of Wireless Equipment/Systems
- F. National Electrical Contractors Association (NECA):
  - 303-2005 .....Installing Closed Circuit Television (CCTV) Systems
- G. National Fire Protection Association (NFPA):
  - 70-08 .....Article 780-National Electrical Code
- H. Federal Information Processing Standard (FIPS):
  - 140-2-02 .....Security Requirements for Cryptographic Modules
- I. Underwriters Laboratories, Inc. (UL):
  - 983-06 .....Standard for Surveillance Camera Units
  - 3044-01 .....Standard for Surveillance Closed Circuit Television Equipment
- J. Homeland Security Presidential Directive 12
- K. Federal Information Processing Standards (FIPS) Publication 201 "Personal Identity Verification (PIV) of Federal Employees and Contractors"

## 1.6 COORDINATION

- A. Coordinate arrangement, mounting, installation, and support of VSS equipment with the Architect, the Owner Representative, and all other trades.
- B. Coordinate installation of required pathways, supporting devices and set sleeves in door frames, cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of VSS cameras and equipment in a secure environment, and in a manner to prevent tampering, or vandalism.

## 1.7 EQUIPMENT AND MATERIALS

- A. All equipment and materials for the VSS will be compatible with other security sub-system components to ensure functional operation in accordance with requirements.
- B. All materials shall be newly manufactured, and designed for the application as described in this specification.

## 1.8 WARRANTY OF CONSTRUCTION.

- A. Warrant VSS equipment and work are subject to the Article "Warranty of Construction" of FAR 52.246-21.
- B. Demonstration and training shall be performed prior to system acceptance.

## PART 2 – PRODUCTS

### 2.1 VIDEO SURVEILLANCE SYSTEM COMPONENTS

- A. Compatibility: All devices shall be provided by the same manufacturer or approved for operation with the core VSS control system. All VSS components shall interface and be compatible with other security sub-system components.
- B. Protection: All components shall be power from UPS circuits. All components shall be grounded in accordance with the manufacturer's guidelines to the facility's single point grounding system.
- C. Tamper Protection: Tamper switches shall be connected and alarmed on all controllers, panels, other security sub-system panels, and other so equipped devices.

### 2.2 CAMERAS

- A. All camera shall be 1/4" CCD chip, with, automatic back-light compensation, automatic gain control, automatic white balance and digital signal processing (DSP). Capabilities should include: zoom, sharpen, smooth, brightness, contrast, edge detection, gray scale vs. color
- B. All camera communications shall be IP based, Power over Ethernet, IEEE 802.3af standard, or later.
- C. All connections shall be made using Category 6 UTP (or better) or fiber optic cable.
- D. Cameras shall be power from Power Over Ethernet (PoE) switches, and where required PoE+. Camera shall be IEEE 802.3af compliant. Fiber connected cameras shall be provided with local power source.
- E. Cameras shall be:
  - 1. Charge coupled device (CCD) cameras and shall conform to National Television System Committee (NTSC) formatting.
  - 2. Cameras shall be color, high resolution, 1080p.
  - 3. The cameras shall operate with low light sensitivity in B/W during low light (monochrome or night mode), automatically switching as the image allows. IP cameras shall provide color and B/W (day/night) models with sensitivity down to 0.12 lux in color and 0.03 lux in B/W.

4. Cameras shall be integrated with infrared (IR) illuminators.
5. Cameras provided shall be both fixed image and Pan/Tilt/Zoom (PTZ) cameras refer to project drawings for quantities and locations.
6. Cameras shall allow an adjustable frame rate between .5 frames per second (fps) and 30 fps.
- F. Each camera shall be fitted with an appropriate lens for the desired image of the area of coverage.
- G. PTZ operation shall be controlled through mouse or keyboard from the SMS control station. PTZ shall be configured with up to 16 preset views and allow for a configurable electronic guard tour of those presets.
- H. Camera connections shall utilize Category 6 cable when carrying signals up to 100 m (300 ft.), when greater fiber optic cable when this distance is exceeded. Use media converters and local power supplies as required to connect security network devices.

## 2.3 LENS

1. All lenses provided shall be equipped with DC auto-iris and auto focus but must allow for manual operation.
2. Fixed image cameras shall be provided with vari-focal lenses to allow fine-tuning of the desired image.

## 2.4 DIGITAL VIDEO MANAGEMENT SYSTEM

- A. The video management system (VMS) shall oversee all functions of the VSS. These include camera selection, PTZ control, image storage/ retrieval, testing and troubleshoot, etc. the VMS software may share a workstation with the SMS control station.
- B. The VMS shall be a PC based control application for user interface.
- C. The VMS shall control all camera, storage systems, and/or appliances.
- D. The VMS stores all recorded images, allows for recorded images retrieval, review, and export. Images shall be stored in an industry standard format such as JPEG, MPEG-4, etc. for easy export from the system.
- E. Playback of recorded images shall not interrupt or interfere with the continued recording of any images. Playback functions will include: video search by onscreen selection of a fence, by date/time; or manually including start, stop, pause, fast forward, reverse, high-speed search.
- F. The VMS shall allow for storage of three months of images and allow external back-up of images to digital video recorder (DVR), DAT tapes, SAN or NAS.
- G. The VMS must interface with the other security sub-systems on this project to provide an integrated security solution.
- H. The VMS shall be capable to expand to address additional cameras, storage systems, etc. without replacement of the current investment.
- I. The VMS will allow for programming of schedules to adjust the performance of the system during occupied or unoccupied periods, during times of heightened security or on demand.
- J. Built-in Video Motion Detection (VMD): Independent of camera model to support all cameras simultaneously. The VMD shall be adjustable in sensitivity and allow for 'fencing' of specific areas of concern.

- K. Export of images from the system shall be available in multiple formats including DVD, USB connected drives, HTTP, FTP, or email.
- L. Integration for alarms, configure the VMS to alert with specific alarms are triggered and respond by bringing the images up at the VMS (or SMS control station), and increasing any nearby cameras to their maximum frame rate.
- M. Integration with ACS for legitimate access and alarms, configure the VMS to alert with specific doors are accessed, or when alarms are triggered; and respond by bringing the images up at the VMS (or SMS control station), and increasing any nearby cameras to their maximum frame rate.
- N. VMS shall allow selection of images to be viewed on the VMS or external monitor. The VMS shall allow for multiplexed images such as 2x2 to 4x4.
- O. The VMS must allow multiple levels of access, based on the login permission of a specific user.
- P. The VMS shall report an alarm in the event of 'loss of video signal'.
- Q. The VMS shall maintain a log of alarm events and TCP/IP events.

## 2.5 VIDEO DISPLAY MONITOR

- A. In addition to the VMS control station, two wall mounted Video Display Monitors shall be provided to display images associated with the VSS, VMS, or the operation of the Security Management System (SMS). These two monitors are located in accordance with the project drawings.
- B. Provide a Video Display Monitor to display images associated with the VSS, VMS, or the operation of the Security Management System (SMS). This monitor is located in accordance with the project drawings.
- C. The monitor shall be commercial grade 42" 1920x1080 LCD display, 1080p, in 16:9 format with 120 hertz refresh rate. This device is anticipated to operate 7x24 (commercial grade).
- D. Provide mounting hardware (wall or ceiling) and all cabling.
- E. Monitor shall be controlled from the VMS control station, and allow for adjustment of: color, tint, brightness, contrast, sharpness, etc.

## 2.6 CAMERA MOUNTS

- A. Camera mounts shall be coordinated with the Architect for the proposed locations.
- B. In drop ceilings, use a recessed camera enclosure. For hard ceilings, use a pendant mount or vandal resistant metallic enclosure.
- C. For exterior cameras use a weathertight outside rated enclosure with incorporated heater.

## 2.7 NETWORK SWITCH

- A. Network switch(es) shall provide backbone connectivity and power to the VSS. Standards compliant, commercially available, manageable Ethernet switches shall be provided in support of the VSS, SMS, PoE IP cameras, and other security sub-system components.
- B. Network Switch Technical Characteristics

Protocol and standard	IEEE802.3 IEEE802.3u IEEE802.3ab
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Ports	24 10/100/1000M auto-negotiation RJ-45 ports with auto MDI/MDI-X
Network media	Cat 6 UTP for 1,000Mbps GBIC with modular F/O port for uplinks
Transmission method	store-and-forward
LED	indicator power, act/link, speed

### PART 3 - EXECUTION

#### 3.1. GENERAL

- A. Installation: The Contractor shall install all system components to integrate (expand) with the Owner's existing equipment, and appurtenances in accordance with the manufacturer's instructions, and as shown, and shall furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable security system.
- B. Identification and Labeling: The Contractor shall supply permanent identification labels for each cable at each end that will appear on the as-built drawings. The labeling format shall be identified and a complete record shall be provided to the Owner with the final documentation. Each cable shall be identified by type or signal being carried and termination points. The labels shall be printed on letter size label sheets that are self-laminated vinyl that can be printed from a computer data base or spread sheet.
- C. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing.
- D. Cameras:
  - 1. Aim camera to give field of view as needed to cover the alarm zone, submit a still image of the scene for approve. Provide bracketed images as alternatives and submit for Owner approval / selection.
  - 2. Focus the lens to give a sharp picture (to include checking for day and night focus and image quality) over the entire field of view
  - 3. PTZ cameras shall have all preset positions and privacy areas defined and programmed.
- E. VSS Control System:
  - 1. Install the video workstation per design and construction documents, and as specified by the Manufacturer. Interface other security system sub-systems for a completely integrated security system. VMS may reside on the same workstation as the integrated SMS control station.
  - 2. Provide application software programming per requirements and as provided by the Owner. Programming shall include:
    - a. Screen views
    - b. Graphical User Interface (GUI) maps, views, icons and actions
    - c. Alarm outputs

d. Reports

F. Network Switch:

1. Install the network switch per design and construction documents, and as specified by the Manufacturer.
2. Configure the network switch per manufacturer's recommendation and project requirements. Coordinate addressing and naming with the Owner.
3. Propose VMD zones for each camera requiring video motion detection, and obtain approval of the Owner. Integrate alarm responses with all security sub-systems.

3.2. GROUNDING

- A. 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.
- B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 10-Ohm to ground (max.).
- C. Comply with installation requirements in Section 27 05 26 "GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS."

3.3 STARTUP, TESTING AND COMMISSIONING

- A. The Commissioning Agent will observe the Contractor startup and test selected equipment. Coordinate the startup and contractor testing schedules with the Owner and Commissioning Agent. Provide a minimum of 7 days prior notice.
- B. Provide ATP plan and commissioning report documentation for all inspection, start up, and contractor testing required above and required by the Owner.

3.4 TRAINING

- A. Provide training for the Owner's Representatives by manufacturer's trained technical representative. Include 24 hours of instruction for Owner's personnel in operation and maintenance of units, with up to four participants to a class.
- C. Submit training plans, schedule, and instructor qualifications to Owner for approval,

-----END OF SECTION-----

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## SECTION 28 36 00 - LEAK DETECTION AND ALARM

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes

1. Water leak detection system including cable sensors, point sensors, interconnecting cable and controller necessary for a complete installation of an integrated Water Leak Detection & Location System.

##### B. Related Requirements (provided by Engineer where applicable)

1. Common work results for Electrical – Section 26 05 00
2. Low-Voltage electrical power conductors & cables – Section 26 05 19
3. Communication Services – Section 27 05 13
4. Hangers and Supports for Communications Systems – Section 27 05 29

#### 1.2 REFERENCES

##### A. Reference Standards

1. NFPA 70 (NEC) – US National Electric Code
2. NEMA 250 – Enclosures for Electrical Equipment

#### 1.3 SUBMITTALS

##### A. Product Data

1. Application information can be obtained from Pentair TRACETEK Leak Detection System Commercial Building Application and Product Selection Guide H53147.
2. Provide Pentair TRACETEK installation & operation manuals for controls and communications, electronic monitoring, sensing products, accessories, and installation tools and equipment.

##### B. Shop Drawings

1. Provide a water leak detection circuit layout drawing detailing the following information for each circuit:
  - a. Point sensors & location
  - b. Cable sensors & location
  - c. Sensor interface modules & location
  - d. Main control panel & location
2. Shop drawings shall include a floor plan map of the building with sensor location & resistance reading at point sensor and cable sensor.

#### 1.4 QUALITY ASSURANCE

##### A. Qualifications

###### 1. Manufacturers

- a. All manufacturers shall have a minimum of thirty years of experience in the manufacturing of water leak detection sensors, cable, controls & equipment.
- b. The manufacturer shall provide written verification of current ISO 9001 registration.

###### 2. Installers

- a. All installers shall be professionally trained and experienced in the installation of water leak detection systems.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

##### A. Storage And Handling Requirements

1. Sensors, cable and controllers shall be stored in a clean and dry location prior to installation of the water leak detection system.
2. Take precautions necessary to prevent damage from contact with sharp objects to cables & sensors.

#### 1.6 SITE CONDITIONS

##### A. Leak Detection Site Conditions

1. Floor area in and around the water leak detection floor sensor shall be cleaned, prepped, sealed and painted prior to the installation of the water sensors.

#### 1.7 WARRANTY

- A. Manufacturer Warranty – Contractor shall provide standard manufacturer's warranty of 24 months from the date of installation of the leak detection system.
- B. Extended Warranty – Contractor shall submit all system testing records to manufacturer to qualify for manufacturer extended warranty on the following products:
  1. TT1000 Sensor Cables – 10 years

### PART 2 - PRODUCTS

#### 2.1 WATER LEAK DETECTION SYSTEM

##### A. Manufacturers

1. Specification is based on Pentair TRACETEK brand water leak detection products.
- B. Contractor to provide a complete water leak detection system including UL approved controls designed for the areas listed below. Contractor to submit system design & system drawings to owner's agent for approval.
- C. Water Sensing Cables and Water Point Sensors
  1. Engineer in collaboration with Rep shall specify the installation off TRACETEK water detection cables and point sensors in all raised floor areas
  2. Manufacturers with Rep shall select from the following TRACETEK water sensing cables and water point sensors depending on the application:
    - a. The water sensing cable (TT1000) shall be a four (4) wire design, with two (2) sensing wires, one (1) alarm wire and one (1) continuity wire embedded in a fluoropolymer carrier rod which can sense the presence of water at any point along its length and shall not detect hydrocarbons. The sensing cable design shall have the ability to provide continuous verification of sensing circuit integrity. The sensing wires shall be jacketed with a conductive fluoropolymer and shall be constructed with no metal parts exposed to the environment for corrosion resistance. Sensing cable shall be quick drying and reset within 15 seconds of removal from free water; sensing cable that is braided in construction is not acceptable. No more than one foot of tap water, in contact with a sensing cable at a depth of 1/16 inch, shall be required to cause an alarm at the electronic alarm module. The water sensing cable shall be UL Listed and rated Type CL2P for plenum use. The sensing cable shall have a tensile breaking strength of 160 pounds and an abrasion resistance of >65 cycles per UL719. The sensing cable shall be vibrant yellow for easy identification within floor voids, drip trays and general service areas. Water sensing cable shall be pre-terminated and modular for quick connection to cables and leak detection components. Soldering or the use of wire nut shall not be a permitted method to join leak detection cable. The sensing cable system shall feature modular branching connectors in order to introduce tee splices into the layout.
- D. Sensor Interface Modules
  1. Contractor shall furnish and install for each leak detection circuit a TRACETEK Sensor Interface Module model.
    - a. TTA-SIM-2 Sensor Interface Module with integrated Form C Relay, Leak Location LCD display, and Audible Alarm

LED Indicators for	Power	Leak	Service	Communication
Display	LCD with leak location			
Communications	RS-485 up to 4000 ft			
Protocols	Modbus	OptoMux	Johnson Metasys	
Max Cable Length	500 feet			
Precision	0.5% of sensor length			
Voltage		120VAC		
Relay – Form C	SPDT	NO or NC	2A @ 250VAC	Software Selectable

Audible Alarm	45 decibels at 2 ft, with Silence Button
Enclosure	Rugged polycarbonate, NEMA1/ IP20 rated
Mounting	4 holes for mounting to any convenient vertical surface

2. The sensor interface module shall continuously monitor the sensor cable for continuity faults. The loss of continuity in any of the wires shall result in an LED indication of the trouble condition, and optional actuation of the alarm relay by user.
3. The number and location of the Sensor Interface Module shall be indicated on the system drawing.
4. The sensor interface module located in Comms 140 shall be recessed mounted in wall.

E. Central Control Panel –CCP:

1. TTDM-128
  - a. The CCP shall be powered by 120 Vac.
  - b. The CCP shall be capable of polling data from up to 127 external Sensor Interface Modules via RS-485 serial data communications using MODBUS, OptoMux or Metasys protocols.
  - c. The CCP shall provide at a minimum a 4 x 20 character LCD display that shall inform the user of the status of each connected Sensor Interface Model and its associated sensor cable circuit. Conditions reported shall include, NORMAL, LEAK DETECTED with LEAK LOCATION, LOOP BREAK, LOOP IMBALANCE, CABLE BREAK, LOST COMMUNICATIONS.
  - d. The CCP shall maintain a user settable real time clock with time recorded to the nearest minute. All significant systems events including leak detection, locations, leak cleared, alarm relay reset, etc. shall be recorded to an Event History log and shall include a date and time stamp. The Alarm panel shall maintain a log of the most recent 2048 events.
  - e. The CCP shall be equipped with Status LEDs for NORMAL (Power on); LEAK; TROUBLE; and SERVICE NEEDED.
  - f. The CCP shall be equipped with summary status relays for LEAK DETECTED, TROUBLE and SERVICE NEEDED. Relay contacts shall be Form-C, Double Pole, Double Throw and rated to at least 5A at 250 VAC.
  - g. The CCP shall scan for all connected Sensor Interface Modules at power up and automatically commence polling of all discovered channels. Any user configuration settings shall be maintained in non-volatile memory. The Alarm Panel shall automatically recover from any loss of power and restart with full functionality without loss of user specific set-up options or event history. For any loss of power exceed 5 minutes, the Alarm Panel shall record a power loss event and a system restart event to the Event History.
  - h. The CCP shall be equipped with a user selectable RS232/RS485 serial port for external communications. The CCP shall be capable of acting as a Modbus slave device and the manufacturer shall provide a Modbus register map allowing a Modbus master device (PC, PLC, DCS, etc.) to access all current status information for any connected SIM including leak detections and locations; all event history; user adjustable set-up parameters and alphanumeric channel and region tags.
  - i. The CCP shall be UL/FM approved.

## 2.2 ACCESSORIES

- A. Contractor to provide all TRACETEK brand modular branch connectors, jumper cables and cable connectors for a complete leak detection system. For additional details refer to Tables 4, 5 and 6 of H53147 Design Guide.

- B. Provide a flush mounted remote alarm annunciator panel in location indicated on drawings that provides both an audible and visual alarm and complete with acknowledge and reset switches. Provide all necessary control wiring in raceway to make a complete system.

## 2.3 COMPONENTS

- A. Example Typical component selections for various applications, as detailed in H53147 Design Guide, are as follows:
- B. Large scale system under raised floor in computer room, data center or server room:
  - 1. Central Control Panel TT-TS12 to manage and display data from network of up to 250 external Sensor Interface Modules.
  - 2. Sensor Interface Modules TTSIM-1A to monitor the status of sensor cables and point sensors.
  - 3. Leader cables TT-MLC-PC or TT-MLC-MC to connect Sensor Interface Modules to sensor cables and point sensors.
  - 4. Point Sensors TT-FLAT-PROBE for sumps and drip trays.
  - 5. Water sensing cable TT1000 or TT3000 for monitoring leaks under raised floors, utility rooms, flat surfaces.
  - 6. Other components including modular jumper cables TT-MJC-X-PC or TT-MJC-X-MC, modular end terminations TT-MET-PC or TT-MET-MC, modular branching connectors TT-MBC-PC or TT-MBC-MC, weighted lengths TT-WL-4.5M/15FT-PC or TT-WL-4.5M/15FT-MC, hold down clips TT-HDC-1/4, and identification tags TT-TAG as required.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. All TRACETEK leak detection system components shall be installed in accordance with the manufacturer's installation instructions, NEC, and local code requirements.
- B. The sensing cable shall be installed after all piping, air conditioning, raised flooring, and other mechanical work has been completed, and prior to installation of other data or power distribution cabling. The sub floor sensing cable path shall remain clear of water, oil, solder, flux, dirt or other materials that may soil the sensing cable. Contractor shall prepare floor surface for cable installation, install hold down clips for sensing cable, route and fix the sensor cable, route and fix any interconnect accessories such as jumper cable, point probes, branch connectors, leader cables and end terminations.
- C. The sensing cable shall be installed beneath the raised flooring and around the perimeter of all rooms, a maximum of three feet from the outside wall. Route the sensing cable a minimum distance of three feet beyond the perimeter of all A/C units. The sensing cable should be kept clear of any sharp edges, floor pedestals and uninsulated ground conductors. In addition, lay the cable in a serpentine pattern, on 4-8 foot minimum centers, to protect interior surface areas where water sources are found, such as A/C unit, CPU piping, floor drains, chillers, etc. The sensing cable should be installed under the center of floor tiles to facilitate access to, and visual location of, leaks. Sensing cable shall be secured to the sub floor with hold-down clips (TT-HDC-1/4) at approximately six-foot intervals and at every change in direction.

- D. The sensor cable shall be on the bottom layer of all cabling in contact with the slab floor and positioned such that it will be in the path of any water leaking from chilled water supply and return lines, valves and fittings in the chilled water system, leaks from condensate tray overflows in air handlers, and similar source of water in the sub-floor and surrounding wall spaces.
- E. The installer shall be responsible for providing a clean and functional system. The installer shall be responsible for installation of the sensing cable, functional testing, and mapping of the system. Contractor shall supply supervision and training to the end user for the leak detection system.
- F. A graphic display map, prepared from "as- built" drawings, shall be furnished upon completion. The map shall indicate the location of the sensing cables, landmarks such as equipment, A/C units, walls, floor drains, change of cable direction, and cable distance readings. The map shall be mounted next to the alarm and locating module.

### 3.2 TESTS

- A. The system shall be tested in accordance with the manufacturer's recommendations and industry standards.

### 3.3 COMMISSIONING

- A. The system shall be commissioned upon completion of the installation by personnel authorized by the manufacturer in accordance with manufacturer's instructions. At this time demonstration and basic operation shall be provided to the owner.
- B. At the time of commissioning the system, the system supplier shall provide the Owner or Owner's
- C. Representative with the name of an authorized manufacturer's Service Contractor who can provide preventive maintenance and service contracts for the leak detection system at least once a year, inclusive of removing debris from sensing cables, ensuring the interconnection and integrity of the electronic components in accordance with the manufacturer's recommendations.

END OF SECTION 28 36 00

## SECTION 28 46 21.11 - ADDRESSABLE FIRE-ALARM 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. Fire-alarm control unit.
  - 2. System smoke detectors.
  - 3. Nonsystem smoke detectors.
  - 4. Notification appliances.
- B. Related Requirements:
  - 1. Section 271513 "Communications Copper Horizontal Cabling" for cables and conductors for fire-alarm systems.

#### 1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.
- F. VESDA: Very Early Smoke-Detection Apparatus.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
  - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
  - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.
  - 1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
  - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
  - b. Show field wiring required for HVAC unit shutdown on alarm.
  - c. Locate detectors according to manufacturer's written recommendations.
  - d. Show air-sampling detector pipe routing.
13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
  - a. Trained and certified by manufacturer in fire-alarm system design.
  - b. NICET-certified, fire-alarm technician; Level III minimum.
  - c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 SAMPLE WARRANTY: FOR SPECIAL WARRANTY.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
    - d. Riser diagram.
    - e. Device addresses.
    - f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
    - g. Record copy of site-specific software.
    - h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
      - 1) Equipment tested.
      - 2) Frequency of testing of installed components.
      - 3) Frequency of inspection of installed components.
      - 4) Requirements and recommendations related to results of maintenance.
      - 5) Manufacturer's user training manuals.
    - i. Manufacturer's required maintenance related to system warranty requirements.
    - j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
- B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

#### 1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
  2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
  3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
  4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
  5. Keys and Tools: One extra set for access to locked or tamperproofed components.
  6. Audible and Visual Notification Appliances: One of each type installed.
  7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
  8. Filters for Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
  9. Air-Sampling Fan: Quantity equal to one for every five detectors, but no fewer than one unit of each type.

#### 1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

#### 1.10 PROJECT CONDITIONS

- A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.
- B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
  2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

- C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

#### 1.11 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

#### 1.12 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
  - 2. Warranty Period: Five years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, UL-certified FM Global-placarded addressable system, with multiplexed signal transmission and voice horn/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### 2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
  - 1. Manual stations.
  - 2. Heat detectors.
  - 3. Flame detectors.
  - 4. Smoke detectors.

5. Duct smoke detectors.
6. Air-sampling smoke-detection system (VESDA).
7. Automatic sprinkler system water flow.
8. Preaction system.
9. Fire-extinguishing system operation.
10. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
8. Activate stairwell and elevator-shaft pressurization systems.
9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
10. Activate preaction system.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
3. Alert and Action signals of air-sampling detector system.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.
6. Loss of communication with any panel on the network.
7. .

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.

6. Display system status on graphic annunciator.

## 2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

## 2.4 FIRE-ALARM CONTROL UNIT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Fire-Lite Alarms, Inc.; a Honeywell International company.
  2. Notifier.
  3. Siemens Industry, Inc.; Fire Safety Division.
  4. SimplexGrinnell LP.
- B. General Requirements for Fire-Alarm Control Unit:
  1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
    - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    - b. Include a real-time clock for time annotation of events on the event recorder and printer.
    - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
    - d. The FACP shall be listed for connection to a central-station signaling system service.
    - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
  2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
  3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
  1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.

2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
1. Pathway Class Designations: NFPA 72, Class B.
  2. Pathway Survivability: Level 0.
  3. Install no more than 100 addressable devices on each signaling-line circuit.
  4. Serial Interfaces:
    - a. One dedicated RS 485 port for central-station operation using point ID DACT.
    - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
    - c. One USB port for PC configuration.
    - d. One RS 232 port for VESDA HLI connection.
    - e. One RS 232 port for voice evacuation interface.
- E. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
  2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
  3. Record events by the system printer.
  4. Sound general alarm if the alarm is verified.
  5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- F. Notification-Appliance Circuit:
1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
  2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
  3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.
- H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
1. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
  2. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

- J. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals shall be powered by 24-V dc source.
  - 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
  - 1. Batteries: Sealed lead calcium.
- L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.5 SYSTEM SMOKE DETECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Bosch Security Systems, Inc.
  - 2. Faraday.
  - 3. Fire-Lite Alarms, Inc.; a Honeywell International company.
  - 4. GE UTC Fire & Security; A United Technologies Company.
  - 5. Notifier.
  - 6. Siemens Industry, Inc.; Fire Safety Division.
  - 7. Silent Knight.
  - 8. SimplexGrinnell LP.
- B. General Requirements for System Smoke Detectors:
  - 1. Comply with UL 268; operating at 24-V dc, nominal.
  - 2. Detectors shall be four-wire type.
  - 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
  - 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
  - 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  - 6. Integral Visual-Indicating Light: LED type, indicating detector has operated.
  - 7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
    - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    - b. Multiple levels of detection sensitivity for each sensor.
    - c. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

D. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

## 2.6 NONSYSTEM SMOKE DETECTORS

A. General Requirements for Nonsystem Smoke Detectors:

1. Nonsystem smoke detectors shall be listed as compatible with the fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
2. Nonsystem smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.

B. Single-Station Smoke Detectors:

1. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac.
2. Auxiliary Relays: One Form C, rated at 0.5 A.
3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet according to UL 464.
4. Visible Notification Appliance: 177-cd strobe.
5. Heat sensor, 135 deg F combination rate-of-rise and fixed temperature.
6. Test Switch: Push to test; simulates smoke at rated obscuration.
7. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
9. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

C. Single-Station Duct Smoke Detectors:

1. Comply with UL 268A; operating at 120-V ac.
2. Sensor: LED or infrared light source with matching silicon-cell receiver.
  - a. Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot when tested according to UL 268A.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
  - a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.7 NOTIFICATION APPLIANCES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Federal Signal Corporation.
  2. GE UTC Fire & Security; A United Technologies Company.

3. Gentex Corporation.
  4. Harrington Signal, Inc.
  5. Keltron Corporation.
  6. Mircom Technologies, Ltd.
  7. Potter Electric Signal Company, LLC.
  8. Siemens Industry, Inc.; Fire Safety Division.
  9. SimplexGrinnell LP.
  10. System Sensor.
  11. Wheelock; a brand of Eaton.
- B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
- D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
- E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- F. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
1. Rated Light Output:
    - a. 15/30/75/110 cd, selectable in the field.
  2. Mounting: Wall mounted unless otherwise indicated.
  3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
  4. Flashing shall be in a temporal pattern, synchronized with other units.
  5. Strobe Leads: Factory connected to screw terminals.
  6. Mounting Faceplate: Factory finished, red.
- G. Voice/Tone Notification Appliances:
1. Comply with UL 1480.
  2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
  3. High-Range Units: Rated 2 to 15 W.
  4. Low-Range Units: Rated 1 to 2 W.
  5. Mounting: Flush.
  6. Matching Transformers: Tap range matched to acoustical environment of speaker location.
- H. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
  1. Devices placed in service before all other trades have completed cleanup shall be re-placed.
  2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
  1. Connect new equipment to existing control panel in existing part of the building.
  2. Connect new equipment to existing monitoring equipment at the supervising station.
  3. Expand, modify, and supplement existing control equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- C. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
  1. Install seismic bracing. Comply with requirements in Section 270548.16 "Seismic Controls for Communications Systems."
  2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  5. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Equipment Mounting: Install fire-alarm control unit on finished floor.
1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."
- E. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."
- F. Smoke- or Heat-Detector Spacing:
1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
  2. Smooth ceiling spacing shall not exceed 30 feet.
  3. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
  4. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
  5. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- G. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
- J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

### 3.3 PATHWAYS

- A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.
  - 1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.
- B. Exposed EMT shall be painted red enamel.

### 3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
  - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
  - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
  - 2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
  - 3. Smoke dampers in air ducts of designated HVAC duct systems.
  - 4. Magnetically held-open doors.
  - 5. Electronically locked doors and access gates.
  - 6. Alarm-initiating connection to elevator recall system and components.
  - 7. Alarm-initiating connection to activate emergency lighting control.
  - 8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
  - 9. Supervisory connections at valve supervisory switches.
  - 10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
  - 11. Supervisory connections at elevator shunt-trip breaker.
  - 12. Data communication circuits for connection to building management system.
  - 13. Data communication circuits for connection to mass notification system.
  - 14. Supervisory connections at fire-extinguisher locations.
  - 15. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
  - 16. Supervisory connections at fire-pump engine control panel.
  - 17. **<Insert connections>.**

### 3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

### 3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

### 3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Perform the following tests and inspections:
  - 1. Visual Inspection: Conduct visual inspection prior to testing.
    - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
  - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
  - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
  - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
  - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
  - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

### 3.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
  - 1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
  - 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
  - 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

### 3.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
  - 1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

### 3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 28 46 21.11

## **SECTION 311000 - SITE CLEARING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Erosion and Sediment Control Planning and Design Manual.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Protection of existing trees.
  - 2. Clearing and grubbing.
  - 3. Removal of trees and other vegetation.
  - 4. Topsoil stripping.

#### **1.3 PAYMENT**

- A. Basis of Payment: Lump Sum

#### **1.4 DEFINITIONS**

- A. Remove: Remove and legally dispose of items indicated. Removal includes digging out and offsite disposing of stumps and roots or burning if allowed by local ordinance.
- B. Tree Protection Zone: The area surrounding individual trees or groups of trees to be protected during construction, as defined by the dripline of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

#### **1.5 MATERIALS OWNERSHIP**

- A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

## 1.6 SUBMITTALS

- A. Photographs or videotape, sufficiently detailed, of existing conditions of trees, plantings and other improvements adjoining the construction that might be misconstrued as damage caused by the Work.

## 1.7 PROJECT CONDITIONS

- A. Traffic: Conduct site clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks or other occupied or used facilities without permission from authorities having jurisdiction.
- B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.
- C. Protect existing improvements on adjoining properties and on Owner's property.
- D. Restore existing improvements damaged by clearing operations to their original condition.
- E. The conditions existing at the time of inspection for bidding purposes will be maintained by the Owner to the extent practical. However, minor variations may occur due to natural occurrences prior to the start of clearing work.
- F. Burning: Burning of combustible materials from demolished structures or vegetation will not be permitted on-site.
- G. Do not commence site-clearing operations until erosion and sedimentation control measures are in place.

## PART 2 - PRODUCTS

### 2.1 TREE PROTECTION FENCING

- A. Tree protection fencing shall be 4 ft. wide, non-tearable, UV resistant orange "safety fence" of 350 lb. tensile strength and 20% elongation at break complying with ASTM D638.
- B. Temporary Barricades: Use only unused and solid lumber of utility grade or better to build temporary barricades surrounding the objects selected for protection, unless otherwise directed by the Engineer.
- C. Pruning Paint: To treat cut or damaged plant tissue, apply only a pruning paint known to be formulated for horticultural applications and accepted by the Engineer.
- D. Other Materials: Any other materials required for completion of the work this Section shall be selected by the Contractor and subject to approval by the Engineer.

## PART 3 – EXECUTION

### 3.1 PROTECTION OF EXISTING TREES AND VEGETATION

- A. Install tree protection fencing as indicated. Erect and maintain a temporary fence around the drip line of individual trees or around the perimeter drip line of groups of trees to remain.
  - 1. Do not store construction materials, debris, topsoil or other excavated material within the tree protection zone.
  - 2. Do not permit vehicles or other equipment within the tree protection zone.
  - 3. Maintain tree protection zones free of weeds and trash.
- B. Protect existing trees and other vegetation indicated to remain in place, against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line.
- C. Provide protection for roots over 1-1/2 inch diameter that are cut during construction operations. Coat cut faces with emulsified asphalt, or other acceptable coating, formulated for use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible.
- D. Repair or replace trees and vegetation indicated to remain which are damaged by construction operations, in a manner acceptable to Engineer.

### 3.2 SITE CLEARING

- A. General: Remove trees, shrubs, grass and other vegetation as required to permit installation of the Work. Cut minor roots and branches of trees indicated to remain in a clean and careful manner, where such roots and branches obstruct installation of the Work.
- B. Clearing and Grubbing: Clear site of trees, shrubs and other vegetation within the clearing limits indicated.
  - 1. Completely remove stumps, roots, and other debris.
  - 2. Use only hand methods for grubbing inside drip line of trees indicated to remain.
  - 3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated. Place fill material in horizontal layers not exceeding 6 inches loose depth, and thoroughly compact to a density equal to adjacent original ground.
- C. Selective Clearing: Clear areas designated as "Selective Clearing" of all ground covers, underbrush and trees less than 6-inches in diameter at breast height. Coordinate extent of material removed with Engineer.

1. Remove trees that appear to be dying or weakening for any reason and at any point during construction up to and including Substantial Completion at the Engineer's direction.

### 3.3 TOPSOIL STRIPPING

- A. Remove heavy growths of grass from areas before stripping.
- B. Strip topsoil to whatever depths are encountered, but to a minimum of at least 4 inches.
- C. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other material.
  1. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
- D. Where existing trees are indicated to remain, leave existing topsoil in place within drip lines to prevent damage to root system.
- E. Temporarily stockpile topsoil in storage piles in areas indicated or directed. Construct storage piles to provide free drainage of surface water. Cover storage piles, if required, to prevent wind erosion.
  1. Do not stockpile topsoil within tree protection zones.
  2. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.
- F. Dispose of unsuitable or excess topsoil in a legal manner off-site.

### 3.4 DISPOSAL OF WASTE MATERIALS

- A. Removal from Owner's Property: Remove waste materials generated by clearing operations from Owner's property and dispose of in a legal manner off-site.
  1. Remove waste materials and debris from the site in a manner to prevent spillage. Pavements and the area adjacent to the site shall remain free from mud, dirt and debris at all times.
  2. Clean up debris resulting from site clearing operations continuously with the progress of the work.

END OF SITE CLEARING

## **SECTION 312000 - EARTHWORK**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to Section 311000 for topsoil stripping.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Excavation, filling, backfilling, and grading indicated and necessary for proper completion of the work.
  - 2. Preparing of subgrade for building slabs, walks, and pavements.
  - 3. Drainage/porous fill course for support of building slabs.
  - 4. Excavating and backfilling of trenches.
  - 5. Excavating and backfilling for underground mechanical and electrical utilities and buried mechanical and electrical appurtenances.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Aggregate Base Course:
  - 1. Basis of Measurement: Lump Sum
- B. Undercut Excavation
  - 1. Basis of Measurement: Cubic Yard
- C. Select Material Backfill
  - 1. Basis of Measurement: Cubic Yard

#### **1.4 SUBMITTALS**

- A. NCDOT approved Job Mix for stone.
- B. Imported fill (if required): Submit location of borrow pit and a copy of the most recent material analysis for approval to the Owner's Geotechnical Engineer a minimum of fourteen (14) working days prior to use
- C. Geotextile Fabric

## 1.5 DEFINITIONS

- A. Excavation: Removal of all material encountered to design subgrade elevations indicated for cut areas and to subsoil elevations in fill areas. Excavation also includes subsequent re-spreading, moisture conditioning, compaction, and grading of satisfactory materials removed.
- B. Unauthorized Excavation: Removal of materials beyond the limits indicated in the definition of "Excavation" without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by the Engineer, shall be performed at the Contractor's expense.
- C. Undercut Excavation: Removal, disposal and replacement of materials beyond the limits indicated in the definition of "Excavation" at the direction of the Engineer. Refer to Part 3 of this Section for requirements of Undercut Excavation. Undercut excavation will be paid for according to the Contract Unit Price Bid for Undercut and Backfill.
- D. Subgrade: The undisturbed earth (in cut) or the compacted soil layer (in fill) immediately below granular subbase, drainage fill, or topsoil materials.
- E. Subsoil: The undisturbed earth immediately below the existing topsoil layer.
- F. Building Pad: The area extending 10 feet beyond the exterior limits of the building/column footings and down to undisturbed soils at a one horizontal to one vertical slope.
- G. Structures: The area extending a minimum of ten (10) feet beyond the edge of foundations, slabs, curbs, underground tanks, piping or other man-made stationary features occurring above or below ground surface.
- H. Pavements: The area extending 10 feet beyond the exterior limits of paved areas and down to undisturbed soils at a one horizontal to one vertical slope. The area extending 3 feet beyond the exterior limits of walks and down to undisturbed soils at a one horizontal to one vertical slope
- I. Base Course Material: Artificially graded mixture of crushed gravel or crushed stone meeting NCDOT specifications. Material type is indicated on the drawings.
- J. Drainage/Porous Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel meeting the requirements of NCDOT No. 57 Stone.
- K. Off-Site Select Borrow: Approved soil material obtained off-site when specified or when sufficient approved soil material is not available from excavations.
- L. Unsuitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that does not meet the definition and requirements of suitable soil.
- M. Suitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that meets the definition and requirements of suitable soil.
- N. Utilities: Underground pipes, conduits, ducts, and cables.

## 1.6 ADDITIONAL WORK

- A. Claims for concealed, unknown, or unanticipated subsurface conditions are limited to those circumstances where:
  - 1. Undercut excavation work is required below the contract limits indicated to provide acceptable bearing for building pad, structures or pavements.
  - 2. Undercut excavation work is required to raise, lower, or revise the footings, foundations or other parts of the building to provide acceptable bearing.
  - 3. Undercut excavation work below the utility trench design elevations, for utilities outside the limits of the building, as required to provide acceptable bearing for the utility.
- B. The risks of concealed, unknown, or unanticipated subsurface conditions from existing ground surface to the design subgrade elevations in cut areas and to subsoil elevations in fill areas shall be included in the Contract Amount and shall not be considered as grounds for additional costs to the Contract. The risks of concealed, unknown, or unanticipated subsurface conditions below the elevations stated above shall be considered as Undercut Excavation.
- C. During construction, if concealed, unknown, or unanticipated subsurface conditions are encountered which require that additional depth of utility trench excavation below the design subgrade or subsoil elevations is required, immediately notify the Engineer upon discovery of such condition prior to disturbing the material encountered.
- D. Payment for additional Work
  - 1. Removal of unsuitable material, if required, shall be at a predetermined price per cubic yard if it is required beyond the following expected removal:
    - a. Two feet outside of concrete work for which forms are required, except footings.
    - b. One foot outside perimeter of footings, two feet below bottom of footings.
    - c. In pipe trenches, 6 inches below invert elevation of pipe and 2 feet wider than outside diameter of pipe, but not less than 3 feet minimum trench width.
    - d. Outside dimensions of concrete work where no forms are required.
    - e. Under slabs on grade, 6 inches below bottom of concrete slab.
  - 2. No payment will be made for unauthorized excavation.

## 1.7 SUBMITTALS

- A. Material Test Reports: Interpreted test results from a qualified testing agency shall be submitted indicating compliance of test results with the following indicated requirements:
  - 1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
  - 2. Laboratory compaction curve according to ASTM D 698 for each on-site and borrow soil material proposed for fill and backfill.

- B. Manufacturer's data on detectable warning tape.

## 1.8 QUALITY ASSURANCE

- A. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.
- B. Environmental Compliance:
  - 1. Comply with the requirements of the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual for erosion control during earthwork operations.
  - 2. Comply with the permit conditions for all work performed within wetlands.
- C. Testing and Inspection Service: Owner will employ and pay for an independent Geotechnical testing and inspection laboratory to perform soil testing and inspection service during earthwork operations. Contractor shall cooperate with Owner's Geotechnical Engineer as required for testing and inspection of work. These services do not relieve the responsibility for compliance with Contract Document requirements.

## 1.9 PROJECT CONDITIONS

- A. Bidders and interested parties (prior to receipt of bids) are encouraged to conduct their own soil and subsurface investigations, examinations, tests, and exploratory borings to determine the nature of the soil conditions underlying the project site. Contact the Owner's representative for permission and scheduling prior to entering the site for the purpose of conducting your own investigation prior to bid.
- B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.
  - 1. Notify Engineer not less than 48 hours in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without receiving Engineer's written permission.
  - 3. Existing utilities across or along the line of work are indicated only in an approximate location. Locate all underground lines and structures. Call "NC one call" at 811 a minimum of three days prior to commencement of construction. If utilities are marked that are not shown on the plans, locate utility vertically and horizontally and provide information to Engineer. Repair and correct any damage to underground lines and structures.

## 1.10 SAFETY

- A. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
  - 1. Operate warning lights as recommended by authorities having jurisdiction and governing regulations and standards.

2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Work within the road right-of-way shall meet all requirements of the latest edition of the North Carolina Department of Transportation Work Area Protection Manual.

## PART 2 - PRODUCTS

### 2.1 SOIL MATERIALS

- A. Suitable soil materials are defined as those complying with ASTM D2487 soil classification groups GC, GW, GP, GM, SM, SW, and SP.
- B. Unsuitable soil materials are defined as those complying with ASTM D2487 soil classification groups CL, SC, CH, OL, OH, MH, ML and PT. Unsuitable soils also include suitable soils not maintained within 2 percent of optimum moisture content at time of compaction and all soils not meeting the requirements for suitable soils.
- C. Backfill and Fill Materials: Satisfactory soil materials free of clay, rock or gravel larger than 4 inches in any dimension (2 inches for material used in trench backfill), debris, waste, frozen materials, vegetation and other deleterious matter.
- D. Imported material for porous fill shall comply with ASTM D2487 soil classification groups GW, GP, SW or SP with a maximum aggregate size of 1.0 inch and no more than 5 percent passing the No. 200 Sieve.
- E. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
- F. Utility/Stone Bedding Material: NCDOT 67 or #57.
- G. Aggregate Base Course Material: NCDOT ABC.

### 2.2 ACCESSORIES

- A. Non-woven Geotextile Fabric (for drainage): Mirafi 140N, or equivalent.
- B. Woven Geotextile Fabric (for reinforcement): AAMCO 2002, or equivalent.
- C. Detectable Warning Tape for Metallic and Nonmetallic Pipe Materials: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 2' 6" deep.
- D. Tape Colors: Provide tape colors to utilities as follows:
  1. Red: Electric.

2. Yellow: Gas.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sanitary Sewer and Storm Sewer systems.
6. Brown: Sewer Force Mains.

## PART 3 – EXECUTION

### 3.1 PREPARATION

- A. Call North Carolina 811 service at 811 or 1-800-632-4949 not less than three working days before performing work.
- B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- C. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 31 10 00 "Site Clearing."
- D. Protect and maintain erosion and sedimentation controls during earthwork operations.

### 3.2 DEWATERING

- A. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.
  1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrade and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
  2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rainwater and water removed from excavations to collecting or runoff areas. Do not use utility trench excavations as temporary drainage ditches.
- B. Should any springs or running water be encountered in the excavation, notify the Engineer and provide discharge by trenches (or other acceptable means) and drain to an appropriate point of disposal. Provide temporary drainage facilities to minimize the flow of rainwater onto adjacent property. Repair any damage to property or to subgrade as a result of construction and/or dewatering (or lack thereof) operations at no additional cost to the Contract. If permanent provision must be made for disposal of water other than as indicated, the Contract price shall be adjusted.
- C. Dispose of water pumped from excavations into ditches or storm drains having the capacity to handle the volume of pumped water.

1. Contractor is responsible for acquiring all permits required to discharge the water and shall protect waterways from turbidity during the operation.
2. Prevent flooding of streets, roadways, or private property.
3. Provide noise attenuated engines when pumps will operate within 500 feet of a residence or commercial establishment.

### 3.3 EXCAVATION

- A. Excavation consists of removal, placement and disposal of material encountered when establishing required subgrade or finish grade elevations.
  1. Excavation includes removal and disposal of pavements and other obstructions visible on ground surface; underground structures, utilities and other items indicated to be demolished and removed; together with earth and other materials encountered that are not classified as unauthorized or excavation.

### 3.4 EXCAVATION FOR BUILDING PAD AND STRUCTURES

- A. Conform to elevations and dimensions indicated within a tolerance of plus or minus 0.10 foot and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction and for review.
- B. Excavations for footings and foundations: Do not disturb bottoms of excavation. Excavate by hand to elevations required just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive other work.
- C. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Structures: Conform to elevations and dimensions indicated within a tolerance of plus or minus 0.10 foot plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction and for review. Do not disturb bottom of excavations intended for bearing surface.

### 3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Cut surface under pavements to comply with cross-sections, elevations and grades as indicated.

### 3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Refer to Section 312317 Trenching and Backfilling for trenching specifications.

### 3.7 EXCAVATION STABILITY

- A. General: Comply with local codes, ordinances, and requirements of agencies having jurisdiction.

- B. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
- C. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses. During excavations, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading, to prevent slides or cave-ins, and to provide adequate access to the work. The Contractor shall comply with the "Rules and Regulations Governing the Construction Industry" as promulgated for the Health, Safety & General Welfare of Employees by the Commission of Labor. Particular attention shall be paid to the following sections:
  - 1. Where unstable material is encountered in excavations over 5' in depth, the sides of the excavations shall be shored or sheet piled unless the sides are sufficiently sloped to eliminate all possibility of a cave-in.
  - 2. Where stable material is encountered in excavations over 5' in depth, the sides of the excavations shall be shored or braced unless the sides are sufficiently sloped to eliminate all possibility of a cave-in.
  - 3. Where workmen are engaged near the edge of the excavation, undercutting of bank or walls is prohibited unless adequately protected.
  - 4. Proper and adequate means of ingress and egress shall be provided at all times from all excavations and trenches; either by ramps, stairways, or ladders located so as to be accessible to workmen at all times.
- D. In addition to the Safety Provisions specified herein, the Contractor shall comply with the Department of Labor, Safety & Health Regulations for Construction promulgated under the Occupational & Health Act of 1970 (PL-596) and under Section 107 of the Contract Work Hours and Safety Standards Act (PL-91-54). Where the requirements of these acts are in excess of those requirements specified, the requirements of these acts shall govern.

### 3.8 SUBGRADE INSPECTION

- A. Notify Engineer when mass, trench and footing excavations are expected to reach required subgrade. The Engineer will arrange for an inspection of conditions by the Owner's Geotechnical Engineer. *Alternative procedures for arranging this review may be implemented at the Owner's written option.*
- B. If the Owner's Geotechnical Engineer determines that the subgrade bearing conditions are unacceptable, the Engineer will authorize additional excavation until suitable bearing conditions are encountered.
- C. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph
  2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
  3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer, and replace with compacted backfill or fill as directed.
- B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

### 3.9 UNDERCUT EXCAVATION

- A. Undercut Excavation: Remove excavated materials and dispose of as directed by the Engineer. Replace this excavated material with satisfactory material placed and compacted according to the requirements of the "Placement and Compaction" section.
- B. Undercut Excavation in Trenches: Remove excavated materials and dispose of on-site as directed by the Engineer. Replace this excavated material with stone.
- C. Undercut Excavation in Footings: Remove excavated materials and dispose of on-site as directed by the Engineer. Replace this excavated material as directed by the Geotechnical Engineer.
- D. Protect the subgrade during construction. During wet conditions, the subgrade soils may become saturated and soften, possibly resulting in damage to the subgrade if disturbed by equipment. Correct subgrade damaged in this manner. **No additional payment will be made to correct subgrade damaged in this manner.**

### 3.10 UNAUTHORIZED EXCAVATION

- A. Correct Unauthorized Excavation as follows:
1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom without altering required top elevation.
  2. Elsewhere, backfill and compact unauthorized excavations as indicated for authorized excavations of same classification unless otherwise directed by Engineer.

### 3.11 STORAGE OF EXCAVATED MATERIALS

- A. Temporarily stockpile excavated materials acceptable for use as backfill and fill. Place, grade, and shape stockpiles for proper drainage.
1. Cover stockpile as necessary to prevent windblown dust or other erosion.

2. Stockpile excavated materials away from edge of excavations. Do not store within the drip line of trees to remain.
3. Stockpile height shall not exceed 15' and side slopes shall be no steeper than 2:1.

### 3.12 BACKFILL AND FILL

- A. Backfill excavations as promptly as work permits, but not until completion of the following:
  1. Acceptance by local authority having jurisdiction of construction below finished grade, including perimeter insulation.
  2. Review, approval, and recording of the locations of underground utilities.
  3. Removal of concrete formwork.
  4. Removal of shoring and bracing (including backfilling of voids with satisfactory materials).
  5. Removal of trash and debris from excavation.
  6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow or ice.
- C. Ground Surface Preparation: Remove vegetation, debris, obstructions, and deleterious materials from ground surface prior to placement of fills.
- D. Bench sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material. Plow, scarify, bench or break up sloped surfaces flatter than 1 vertical to 4 horizontal so fill material will bond with existing material.
- E. Place soil material in layers to required subgrade elevations, for each area classification listed below, using materials indicated in Part 2 of this Section.
  1. Under grassed areas, use suitable excavated or borrow material to within 4" of final grade.
  2. Under walks, curbs, and pavements, use suitable excavated or borrow material.
  3. Under building slabs, use suitable excavated or borrow materials and drainage/porous fill material as indicated.

### 3.13 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Place and compact initial backfill, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- D. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
- E. Place and compact remaining backfill of satisfactory soil to final subgrade elevation in 6" lifts in traffic areas and 12" lifts in no-traffic areas.
- F. Install warning tape directly above utilities as shown in the contract drawings.
- G. Do not backfill trenches until any required testing and inspections have been completed and Engineer authorizes backfilling. Backfill carefully to avoid damage or displacement of pipe systems.
- H. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

### 3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  1. Do not place backfill or fill soil material on surfaces that are wet, frozen, or contain frost or ice.
  2. Remove and replace or scarify and air dry otherwise suitable soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
- B. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations. Maintain the moisture content of the structural fill materials to within 2% of the optimum moisture content until permanently covered.
- C. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to required density.
  1. Stockpile or spread soil material that has been removed because it is too wet to permit compaction. Assist drying by disking, harrowing, or pulverizing until moisture content is reduced to a satisfactory value.
  2. Work wet materials as directed by the Owner's Geotechnical Engineer. Base bids on working material daily for a maximum of five days of acceptable weather.
  3. No additional payment will be made for these operations.

### 3.15 COMPACTION OF SOIL BACKFILL AND FILLS

- A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are wet, frozen, or contain frost or ice.
- C. Control soil and fill compaction, providing minimum percentage of density indicated for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Engineer if soil density tests indicate inadequate compaction.
- D. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density at a moisture content within 2% of optimum in accordance with ASTM D698:
  - 1. Under structures, building pad and pavements, compact each layer of backfill or fill material at 95 percent maximum density. This includes ground under future expansion areas.
  - 2. Under grass or unpaved areas, compact each layer of backfill or fill material at 90 percent maximum density.

### 3.16 GRADING

- A. General: Rough grading of areas within the Project, including cut and fill sections and adjacent transition areas, shall be reasonably smooth, compacted and free from irregular surface changes. The degree of finish shall be that ordinarily obtainable from either blade-grader or motor patrol except as otherwise indicated. The finished subgrade surface from the grassed areas generally shall be not more than 0.1 feet above or below the final grade or approved cross section, with due allowance for topsoil.
- B. The tolerance for areas within 10 feet of building perimeter, walks and all areas to be paved shall not exceed 0.10 feet above or below the established subgrade. Finish all ditches, swales and gutters to drain readily. Unless otherwise indicated, evenly slope the subgrade to provide drainage away from building walls in all directions at a grade not less than  $\frac{1}{4}$  inch per foot. Provide rounding at top and bottom of cut and fill slopes and at other breaks in grade.
- C. Protection of Graded Areas: Protect newly graded areas and areas of cut, fill and design/subgrade elevations from the actions of the elements and from deterioration as a result of construction operations and weather conditions (frost, rains, snow, sleet, hail, etc.). Repair any settlement or washing that occurs prior to or after acceptance of the work. Fill to required subgrade levels any areas where settlement occurs. Protect trees to remain, and, at all areas of the Site where construction operations are in progress, provide protection for the safety of occupants of the existing facilities.

- D. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - 1. Provide a smooth transition between adjacent existing grades and new grades.
  - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- E. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
  - 1. Lawn or Unpaved Areas: Plus or minus 1 inch.
  - 2. Walks: Plus or minus 1/2 inch.
  - 3. Pavements: Plus or minus 1/4 inch.
- F. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

### 3.17 PAVEMENT SUBBASE COURSE:

- A. General: Place subbase material, in layers of indicated thickness, over subgrade surface to support a pavement base course.
- B. Grade Control: During construction, maintain lines and grades including crown and cross-slope of subbase course.
- C. Shoulders: Place shoulders along edges of subbase course to prevent lateral movement. Construct shoulders of suitable soil materials placed in such quantity to compact to thickness of each subbase course layer. Compact and roll at least at 12" width of shoulder simultaneously with compacting and rolling each layer of subbase course.
- D. Placing: Place subbase course material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting subbase material during placement operations.
- E. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- F. On prepared subgrade, place subbase and base course under pavements and walks as follows:
  - 1. Install separation geotextile, as necessary per geotechnical report, on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  - 2. Place base course material over subbase course under hot-mix asphalt pavement.
  - 3. Shape subbase and base course to required crown elevations and cross-slope grades.
  - 4. Place subbase and base course 6 inches or less in compacted thickness in a single layer.

5. Place subbase and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
  6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 100 percent of that obtained by compacting a sample of the material in accordance with AASHTO T 99 as modified by NCDOT.
- G. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 100 percent of that obtained by compacting a sample of the material in accordance with AASHTO T 99 as modified by NCDOT.

### 3.18 FIELD QUALITY CONTROL

- A. Quality Control Testing During Construction: Allow testing service to inspect and approve each subgrade and fill layer before further backfill or construction work is performed.
  1. If in the opinion of the Engineer, based on testing service reports and inspection, subgrade or fills have been placed that are below required density, perform additional compaction and testing until required density is obtained.
- B. The Owner will engage, and pay for, the services of a Geotechnical Engineer whose function shall be to afford complete engineering control by testing of the conditions of all footing subgrades, the placement of all structural fills under structures, building pad and pavement areas, and all compaction where required, and to observe the proof rolling of the building pad and pavement areas.
- C. The Owner's Geotechnical Engineer will be present as deemed necessary during all phases of the Work requiring filling, compaction operations or testing. The Geotechnical Engineer will provide the Engineer with written certification that fill and compaction was completed with accepted materials in accordance with the Documents, and give a professional opinion regarding shrinkage or settlement of fill and safe load bearing capacity of fill.
- D. Site Preparation and Proof rolling: The Owner's Geotechnical Engineer will determine if any additional excavation or in-place densification is necessary to prepare a subgrade for fill placement for slab or pavement support.
- E. Fill Placement and Compaction: The Owner's Geotechnical Engineer will witness all fill operations and take sufficient in-place density tests to verify that the indicated degree of fill compaction is achieved. The Owner's Geotechnical Engineer will observe and approve borrow materials used and shall determine if their existing moisture contents are suitable/acceptable.
- F. Footing Excavation Review: The Owner's Geotechnical Engineer will review the footing excavations for the building foundations. He will verify that the design bearing

pressures are available and that no loose or soft areas exist beneath the bearing surfaces of the footing excavations.

- G. The Owner's Geotechnical Engineer will submit copies each of his reports, recommendations and/or opinions to the Engineer/Architect and the Owner. Pertinent information will be provided to the Contractor as required.

### 3.19 EROSION CONTROL:

- A. Provide erosion control methods in accordance with requirements of authorities having jurisdiction, the North Carolina Erosion and Sediment Control Planning and Design Manual, and as indicated in the Contract Documents.

### 3.20 PROTECTION

- A. Repair and reestablish grades in settled, eroded, and rutted areas to indicated tolerances.
- B. Reconditioning Compacted Areas: Where subsequent construction operations or adverse weather disturbs completed compacted areas, scarify surface, reshape, and compact to required density prior to further construction.
- C. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.
- D. Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees Fahrenheit.

### 3.21 DISPOSAL OF WASTE MATERIALS

- A. Removal from Owner's Property: Remove excess and/or waste materials, including trash and debris, and dispose of it off Owner's property in a legal manner.
- B. Dispose of excess material and materials not acceptable for use as backfill or fill legally offsite.
- C. Do not remove topsoil from site until it has been demonstrated to the Owner's satisfaction that it is excess.

END OF EARTHWORK

## **PART 1 SECTION 312317 - TRENCHING AND BACKFILLING**

### **PART 2 GENERAL**

#### **2.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.

#### **2.2 SUMMARY**

- A. Section Includes:
  - 1. Excavating trenches for utilities.
  - 2. Compacted fill from top of utility bedding sub-grades or finish grades.
  - 3. Backfilling and compaction.

#### **2.3 MEASUREMENT AND PAYMENT**

- A. Unclassified excavation:
  - 1. No measurement or direct payment will be made for the Work under this Section and all costs for same shall be included in the price bid for the utility or structure to which it pertains.

#### **2.4 REFERENCES**

- A. American Association of State Highway and Transportation Officials:
  - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
  - 2. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  - 3. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).
  - 4. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
  - 5. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  - 6. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

7. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

## 2.5 DEFINITIONS

- A. Off-Site Select Borrow: Approved soil material obtained off-site when specified or when sufficient approved soil material is not available from excavations.
- B. Unsuitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that does not meet the definition and requirements of suitable soil.
- C. Suitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that meets the definition and requirements of suitable soil.
- D. Topsoil: Soil produced from stripping the top or upper soil layer from areas to be further excavated, re-landscaped, or re-graded without contamination from the subsoil. Stripping of topsoil is not required where excavation width is less than 10' or for the installation of pipe utilities. Topsoil shall be stockpiled on site at designation location for further use. Topsoil shall not be removed from site.
- E. Backfill: Soil material or controlled low-strength material used for fill and excavation.
- F. Base Course: The layer placed between the sub-grade and surface pavement in a paving system.
- G. Excavation: Removal of material encountered above sub-grade elevations and to the lines and dimensions indicated.
- H. Fill: Soil materials used to raise existing grades.
- I. Porous Fill: Fill material supporting the slab on grade that also minimizes upward capillary flow of water.
- J. Structures: Buildings, slabs, curbs, utility appurtenances, tanks, retaining walls or other man-made stationary features constructed above or below ground surface.
- K. Sub-grade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below topsoil materials.
- L. Unauthorized excavation: Removal of materials beyond indicated sub-grade elevations or dimensions without direction by the Town Public Utilities Department. Unauthorized excavation, as well as remedial work directed by the Town Public Utilities Department, shall be at the Contractor's expense.
- M. Undercut excavation: Excavation below sub-grade elevations or beyond indicated lines and dimensions as directed by the Town Public Utilities Department. Authorized undercut excavation and replacement material will be paid for according to Contract unit price for UNDERCUT and BACKFILL.

- N. Utilities: On-site underground pipes, conduits, ducts and cables.

## 2.6 SUBMITTALS

- A. Material Test Reports: Interpreted test results from a qualified testing agency shall be submitted indicating compliance of test results with the following indicated requirements:
  - 1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
  - 2. Laboratory compaction curve according to ASTM D 698 for each on-site and borrow soil material proposed for fill and backfill.
- B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.
- C. Manufacturer's data on detectable warning tape.

## 2.7 QUALITY ASSURANCE

- A. Perform work and provide materials in accordance with North Carolina Department of Transportation Standard Specifications for Roads and Structures, latest edition.
- B. North Carolina Erosion and Sediment Control Planning and Design Manual.
- C. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

## 2.8 QUALIFICATIONS

- A. Use an adequate number of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section
- B. Use a sufficient number of equipment of adequate size and capacity to accomplish the work in a timely manner.

## 2.9 JOB CONDITIONS

- A. Existing Utilities:

1. The existence and locations of underground utilities indicated on the Contract Drawings are not guaranteed and shall be investigated and verified in the field by the Contractor before starting work. Excavations in the vicinity of existing structures and utilities shall be done carefully by hand.
2. Locate existing utilities lines using an electronic pipe finder or other approved means. Uncover these utilities by hand excavation and provide protection from damage. Cooperate with Owner and utility companies for maintaining services. Do not break connections without providing temporary services, as acceptable to the Town Public Utilities Department.
3. Locate, excavate, and expose all existing underground lines before beginning trenching operations.
4. The Contractor will be held responsible for the workmanlike repair of any damage done to any of these utilities in the execution of his work under this Section.
5. The Contractor shall familiarize himself with the existing conditions of these utilities. He shall be prepared to adequately safeguard himself, the utilities, and the Owner from damage.
6. Necessary arrangements shall be made by the Contractor with all persons, firms, corporations owning or using any poles, pipes, tracks or conduits, etc., affected by the construction included under this Section to maintain and protect such facilities during construction. The cost of any such protection shall be paid by the Contractor and included in the Contract price.
7. In the event that any existing gas pipes, water pipes, conduits, sewers, tile drains, poles or other utilities are blocked or interfered with by construction operations, the Contractor shall maintain them in continuous operation and restore them to the same condition as they were prior to the start of construction on this project, all at no additional compensation.

B. Utility Notification:

1. Call NC One Call service at 811 not less than three working days before performing work.

C. Protecting Trees, Shrubbery, and Lawns:

1. Trees and shrubbery in developed areas and along the trench line shall not be disturbed unless absolutely necessary and subject to the approval of the Town Public Utilities Department.
2. Any trees and shrubbery for which removal is necessary shall be heeled in and replanted.
3. Where trenches cross private property through established lawns, sod shall be cut, removed, stacked and maintained in suitable condition until replacement is approved by the Town Public Utilities Department.
4. Topsoil underlying lawn areas shall be removed and kept separate from general excavated materials.

D. Clearing:

1. Perform all clearing necessary for installation of the complete work.
2. Clearing shall be performed in accordance with Section 31 10 00 Site Clearing.

E. Removing and Resetting Fences:

1. Where existing fences must be removed to permit construction of utilities:
  - a. Remove such fences and, as the Work progresses, reset the fences in their original location and condition.
  - b. Fencing must be replaced at the end of each working day.

F. Restoration of Disturbed Areas:

1. Restore all areas disturbed by, during, or as a result of construction activities to their previous or better condition.

2.10 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

2.11 COORDINATION

- A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 3 PRODUCTS

3.1 SOIL MATERIALS

- A. Suitable Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, GC, SW, SP, and SM or a combination of these groups; free of: rock or gravel larger than 1-1/2 inches in any dimension, debris, waste, frozen materials, vegetation, and other matter.
- B. Unsuitable Soils: ASTM D 2487 Soil Classification Groups SC, ML, CL, OL, MH, CH, OH, and PT or a combination of these groups.
1. Unsuitable soils also include suitable soils not maintained within 2 percent of optimum moisture content at time of compaction and all soils not meeting the requirements for suitable soils.
- C. Native material: Soils as excavated from the trench excavation. Where specifically directed by the Town Public Utilities Department, native material may be used for trench backfill.
- D. Porous Fill: ASTM D 2487 soil classification groups GW, GP, SW, or SP with a maximum aggregate size of 1.0 inch and no more than 5 percent passing the No. 200 sieve.

- E. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
- F. Utility/stone bedding material: NCDOT #67 or #57.
- G. Aggregate Base Course Material: NCDOT ABC.

### 3.2 EXCAVATED MATERIALS

- A. Perform all excavation of every description and of whatever substances encountered to depths indicated or specified.
- B. Pile material suitable for backfilling in an orderly manner at a safe distance from banks or trenches to avoid overloading and to prevent slides or cave-ins.
- C. Remove and deposit unsuitable or excess material as directed by the Town Public Utilities Department.

### 3.3 ACCESSORIES

- A. Detectable Warning Tape for Metallic and Nonmetallic Pipe Materials:
  - 1. Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 2'-6" deep.
  - 2. Color: Blue
  - 3. Text: "CAUTION – WATER LINE BURIED BELOW"
- B. Detectable Tracer Wire: At all locations where pressure piping is installed and at lateral locations, non-ferrous or ferrous materials, the contractor shall install a continuous length of #12 solid copper wire, on top and parallel to the pipe.

## PART 4 EXECUTION

### 4.1 LINES AND GRADES

- A. Lay pipes to lines and grades indicated on Drawings.
  - 1. Town Public Utilities Department reserves right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.
- B. Use laser-beam instruments with qualified operator to establish lines and grades.

#### 4.2 EXAMINATION AND PREPARATION

- A. Call NC One Call service at 811 not less than three working days before performing work.
- B. Identify required lines, levels, contours, and datum locations.
- C. Notify Town Public Utilities Department of unexpected subsurface conditions and discontinue affected work in area until notified to resume work.

#### 4.3 PROTECTION OF UTILITIES

- A. Unless shown to be removed, protect active utility lines shown on the drawings or otherwise make them known to the Contractor prior to trenching. If damaged, repair or replace at no additional cost to the Owner.
- B. If active utility lines are encountered and are not shown on the Drawings or otherwise made known to the Contractor, promptly take necessary steps to assure that service is not interrupted.
- C. If service is interrupted as a result of work under this Section, immediately restore service by repairing the damaged utility at no additional cost to the Owner.
- D. If existing utilities are found to interfere with the permanent facilities being constructed under this Section, immediately notify the Town Public Utilities Department and secure his instructions.
- E. Do not proceed with permanent relocation of utilities until written instructions are received from the Town Public Utilities Department.
- F. Locations within streets or highways:
  - 1. Take all precautions and comply with all requirements as may be necessary to protect the improvements, including barricades for protection of traffic.
  - 2. Keep a minimum of one lane open to traffic at all times where utility crosses street or highway.

#### 4.4 PROTECTION OF PERSONS AND PROPERTY

- A. Barricade open holes and depressions occurring as part of the Work, and post warning lights on property adjacent to or with public access.
- B. Operate warning lights during hours from dusk to dawn each day and as otherwise required.

- C. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, washout and other hazards created by operations under this Section.
- D. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- E. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- F. Establish temporary traffic control and detours, when necessary, when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

#### 4.5 DEWATERING

- A. Prevent surface water and groundwater from entering excavations, from ponding on prepared sub-grades, and from flooding project site and surrounding area.
- B. Protect sub-grades from softening, undermining, washout, and damage by rain or water accumulation.
  - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations.
  - 2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavation as temporary drainage ditches.
  - 3. Do not use excavated trenches as temporary drainage ditches.
- C. Maintain the water level below the excavation sub-grade during excavation and construction.
  - 1. Material disturbed below the foundation sub-grade due to improper dewatering shall be removed and replaced with stone bedding material at no expense to the Owner.
  - 2. Dewatering by trench pumping will not be permitted if migration of fine grained natural material (running sand) from bottom, side walls, or bedding material will occur.
- D. Dispose of water pumped from excavations into ditches or storm drains having the capacity to handle the volume of pumped water.
  - 1. Contractor is responsible for acquiring all permits required to discharge the water and shall protect waterways from turbidity during the operation.
  - 2. Prevent flooding of streets, roadways, or private property.
  - 3. Provide noise attenuated engines when pumps will operate within 500 feet of a residence or commercial establishment.

#### 4.6 TRENCHING

- A. Excavate for utilities to the lines and grades per the drawings.
- B. Cut trenches sufficiently wide to enable installation of utilities and allow inspection.
- C. Do not advance open trench more than 400 feet ahead of installed pipe.
- D. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and utility.
- E. Do not interfere with 45 degree bearing splay of foundations.
- F. When Project conditions permit, slope side walls of excavation starting 2 feet above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this section.
- G. When subsurface materials at bottom of trench are loose or soft notify Town Public Utilities Department, and request instructions.
- H. Hand trim excavation and leave free of loose matter. Hand trim for bell and spigot pipe joints.
- I. Stockpile excavated material that is suitable for re-use as directed in 31 00 00 Earthwork, 3.7 Storage of Materials.
- J. Remove from site any excavated material that is unsuitable for re-use.
- K. Where trenching occurs in existing lawns, remove turf in sections and keep damp. Replace turf upon completion of the backfilling.
- L. Open cut:
  - 1. Excavate for utilities by open cut.
  - 2. If conditions at the site prevent such open cut, and if approved by the Town Public Utilities Department, tunneling may be used.
  - 3. Short sections of a trench may be tunneled if, in the opinion of the Town Public Utilities Department, the conductor can be installed safely and backfill can be compacted properly into such tunnel.
- M. Special requirements relating to excavation for water distribution lines:
  - 1. Do not excavate trench more than 400' ahead of pipe laying, unless permitted by Town Public Utilities Department
  - 2. Provide depth of cover shown or minimum cover of 36", whichever is greater.
  - 3. Where minimum cover only is required, carry excavations to depths necessary to properly grade the pipe on tangents and vertical curves as directed by the Town Public Utilities Department.

4. Provide minimum clearance of 6" between pipe walls and trench walls or sheeting and bracing lines.
  5. If minimum cover of 36" cannot be provided, then thermoplastic piping may not be used. Use ductile iron piping or other Town Public Utilities Department-approved material.
  6. If an unacceptable bearing surface is encountered during excavation, notify the Town Public Utilities Department immediately. Town Public Utilities Department may authorize excavation below invert elevation for the introduction of bedding material. Authorized undercut excavation and replacement material will be paid for according to Contract unit price for Undercut and Backfill.
  7. If authorized bedding material is off-site select borrow or stone bedding material, they shall be paid for according to the respective unit price.
  8. If bedding material is required, pipe must be supported during placement and compaction of such material.
- N. Correct over-excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Town Public Utilities Department.

#### 4.7 EXCAVATION AND TRENCH SAFETY

- A. During excavations, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading, to prevent slides or cave-ins, and to provide adequate access to the work. The Contractor shall comply with the "Rules and Regulations Governing the Construction Industry" as promulgated for the Health, Safety & General Welfare of Employees by the Commission of Labor. Particular attention shall be paid to the following sections:
1. Where unstable material is encountered in excavations over 5' in depth, the sides of the excavations shall be shored or sheet piled unless the sides are sufficiently sloped to eliminate all possibility of a cave-in.
  2. Where stable material is encountered in excavations over 5' in depth, the sides of the excavations shall be shored or braced unless the sides are sufficiently sloped to eliminate all possibility of a cave-in.
  3. Where workmen are engaged near the edge of the excavation, undercutting of bank or walls is prohibited unless adequately protected.
  4. Materials which are excavated shall be placed so that the base of the pile is not less than 2' from the edge of the excavation.
  5. Proper and adequate means of ingress and egress shall be provided at all times from all excavations and trenches; either by ramps, stairways, or ladders located so as to be accessible to workmen at all times.
- B. In addition to the Safety Provisions specified herein, the Contractor shall comply with the Department of Labor, Safety & Health Regulations for Construction promulgated under the Occupational & Health Act of 1970 (PL-91-596) and under Section 107 of the Contract Work Hours and Safety Standards Act (PL-91-54). Where the requirements of these acts are in excess of those requirements specified, the requirements of these acts shall govern.

#### 4.8 BACKFILLING

- A. Prior to backfilling, remove all debris, trash, organic material, formwork, temporary shoring and bracing from excavation. Perform all testing and inspection of underground utilities.
- B. Place and compact initial backfill of suitable soil material or sub-base material, free of particles larger than 1 inch, to a height of 12 inches over the utility.
- C. Carefully compact material under pipe haunches. Bring backfill up evenly on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- D. Install warning tape directly above utilities at 12" below final grade, except 6" below sub-grade under paved areas and slabs.
- E. Final backfill areas to contours and elevations. Use unfrozen and unsaturated materials.
- F. Backfill systematically, as early as possible, to allow maximum time for natural settlement. Do not backfill over-porous, wet, frozen, or spongy sub-grade surfaces.
- G. Initial Backfill:
  - 1. Place approved backfill and bedding material in layers of 8 inches maximum thickness, and compact with suitable tampers to the density of the adjacent soil until there is cover of not less than 24" over sewers and 12" over other utilities.
- H. Remainder of backfill:
  - 1. Wooded, undeveloped areas and swamps:
    - a. Place approved backfill and bedding material in layers of 12-18" maximum thickness, and compact with suitable tampers.
    - b. Tamping may be ceased when backfill exceeds 30" over the pipe.
    - c. Mound excess material 6" above grade to provide for settlement.
  - 2. Lawns and unpaved areas:
    - a. Place approved backfill and bedding material in layers of 12-18" maximum thickness, and compact with suitable tampers.
    - b. Obtain a compaction of 90% of maximum dry density.
  - 3. Paved areas, slabs on grade, site concrete flatwork and other similar areas:
    - a. Place approved backfill and bedding material in layers of 8 inches maximum thickness, and thoroughly compact with heavy duty mechanical tampers.
    - b. Obtain a compaction of 98% of an ASTM D698 Standard Proctor.

- I. Maintain optimum moisture content of backfill materials to attain required compaction density.
  - 1. Uniformly moisten or aerate sub-grade and each subsequent fill or backfill soil layer to within 2 percent of optimum moisture content before compaction.
  - 2. Remove and replace, or scarify and air dry otherwise suitable soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
- J. Do not leave more than 20 feet of trench open at end of working day.
- K. Protect open trench to prevent danger to the public.

#### 4.9 TOLERANCES

- A. Top Surface of Backfilling Under Paved Areas: Plus or minus one (1) inch required elevations.
- B. Top Surface of General Backfilling: Plus or minus one (1) inch from required elevations.

#### 4.10 FIELD QUALITY CONTROL

- A. Testing Agency Services: Owner will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports. Allow testing agency to inspect and test each sub-grade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.
- B. Perform laboratory material tests in accordance with ASTM D698 (Standard Proctor).
- C. Perform in place compaction tests in accordance with the following:
  - 1. Density Tests: ASTM D1556 (sand cone) or ASTM D2922 (nuclear) as applicable.
- D. Frequency of Tests:
  - 1. Building slab areas: At sub-grade and at each compacted fill and backfill layer, at least 1 test every 2000 sq. ft., but in no case less than 3 tests.
  - 2. Parking areas and roadways: At sub-grade and at each compacted fill and backfill layer, perform at least one field in place density test every 5000 sq. ft. or less of paved area, but in no case less than 3 tests.
  - 3. Trench backfill: In paved areas, test as above. In lawns and unpaved areas, test final backfill layer with one field in-place density test for each 250 feet of trench. In wooded, undeveloped areas, testing is not required.

- E. When testing agency reports that sub-grades, fills, or backfills are below specified density, then scarify, moisten, aerate, or replace soils. Re-compact and re-test as necessary to achieve required density.

#### 4.11 PROTECTION OF FINISHED WORK

- A. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF TRENCHING AND BACKFILLING

## **SECTION 312513 - EROSION CONTROLS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.
- B. North Carolina Erosions and Sediment Control Planning and Design Manual.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Stone Check Dam
  - 2. Temporary Gravel Construction Entrance
  - 3. Silt Fence
  - 4. Rock Energy Dissipater
  - 5. Block and Gravel Inlet Protection

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Stone Check Dam
  - 1. Basis of Measurement: Per Lump Sum.
  - 2. Basis of Payment: Includes necessary excavation, riprap, filter stone and required maintenance throughout the Contract time.
- B. Temporary Gravel Construction Entrance
  - 1. Basis of Measurement: Per Lump Sum.
  - 2. Basis of Payment: Includes site clearing, stripping, excavating, backfilling, placing rock, and required maintenance throughout the Contract time.
- C. Silt Fence
  - 1. Basis of Measurement: Per Lump Sum.
  - 2. Basis of Payment: Includes excavating, vegetation removal, installation and continued maintenance throughout the Contract time.
- D. Rock Energy Dissipater
  - 1. Basis of Measurement: Per Lump Sum.

2. Basis of Payment: Includes excavating, removing unsuitable material, backfilling, placing geotextile fabric, placing riprap, backfilling edges and continued maintenance throughout the Contract time.

E. Block and Gravel Inlet Protection

1. Basis of Measurement: Per lump sum.
2. Basis of Payment: Block and gravel inlet protection is to be included in the unit price paid for the corresponding drainage structure. No separate payment will be made.

F. Rock Pipe Inlet Protection

1. Basis of Measurement: Per Lump Sum.
2. Basis of Payment: Includes necessary excavation, riprap, filter stone and required maintenance throughout the Contract time.

G. Riprap Channel Lining

1. Basis of Measurement: Lump Sum
2. Basis of Payment: Includes excavating, removing unsuitable material, backfilling, placing geotextile fabric, placing riprap, backfilling edges, and continued maintenance throughout the Contract time.

## 1.4 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T88 - Standard Specification for Particle Size Analysis of Soils.
2. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. American Concrete Institute:

1. ACI 301 - Specifications for Structural Concrete.

C. ASTM International:

1. ASTM C127 - Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.
2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).
3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
4. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
5. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

D. Precast/Prestressed Concrete Institute:

1. PCI MNL-116S - Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products.

1.5 SUBMITTALS

- A. Geotextile fabric
- B. Filter fabric

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with requirements of Section 31 00 00 – Earthwork, Section 31 10 00 – Site Clearing, and Section 31 37 00 – Riprap.
- B. Perform work and provide materials in accordance with North Carolina Department of Transportation Standard Specifications for Roads and Structures, July 2006 edition.
- C. North Carolina Erosion and Sediment Control Planning and Design Manual.
- D. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

PART 2 PRODUCTS

2.1 ROCK AND GEOTEXTILE MATERIALS

- A. Furnish materials and rock in accordance with North Carolina Department of Transportation Standard Specifications for Roads and Structures, July 2006 edition.
- B. Geotextile Fabric: Manufacturer's standard non-woven pervious geotextile fabric of polypropylene, nylon or polyester fibers, or a combination.
  1. Provide geotextile fabrics that meet or exceed the listed minimum physical properties determined according to ASTM D 4759 and the referenced standard test method in parentheses:
    - a. Grab Tensile Strength (ASTM D 4632): 200 lb.
    - b. Apparent Opening Size (ASTM D 4751): #60 U.S. Standard sieve.
  2. Acceptable geotextile fabrics include: Propex Geotex® 801 or approved equal.

- C. Filter Fabric: Manufacturer's standard woven pervious geotextile fabric of polypropylene, nylon or polyester fibers, or a combination.
1. Provide filter fabrics that meet or exceed the listed minimum physical properties determined according to ASTM D 4759 and the referenced standard test method in parentheses:
    - a. Standard-strength filter fabric:
      - 1) Grab Tensile Strength (ASTM D 4632): 50 lb.
      - 2) Elongation (ASTM D 4632): 30% maximum.
      - 3) Apparent Opening Size (ASTM D 4751): #30 U.S. Standard sieve.
      - 4) Permittivity (ASTM D 4491): 0.15/sec.
    - b. Extra-strength filter fabric:
      - 1) Grab Tensile Strength (ASTM D 4632): 100 lb.
      - 2) Elongation (ASTM D 4632): 25% maximum.
      - 3) Apparent Opening Size (ASTM D 4751): #30 U.S. Standard sieve.
      - 4) Permittivity (ASTM D 4491): 0.15/sec.
    - c. Propex Geotex® 102F satisfies both sets of requirements and may be used for silt fence construction; however, an approved equal may also be substituted.

## 2.2 CONCRETE MASONRY UNITS

- A. Concrete masonry units shall conform to ATSM C90.
- B. Unit compressive strength: Provide units with a minimum average net-area compressive strength of 1900 psi.
- C. Weight Classification: Lightweight.
- D. Size: 8"x8"x16" nominal. Manufactured to dimensions 3/8" less than nominal.

## 2.3 ACCESSORIES

- A. Mortar and Grout: (Per NCDOT 1040-8)
  1. Portland cement: ASTM C 150, Type I or II.
  2. Hydrated lime: ASTM C 207, Type S.
  3. Masonry cement not permitted.
  4. Mortar Cement: ASTM C 1329.
  5. Aggregate for mortar: ASTM C 144.

6. Aggregate for grout: ASTM C 404.
  7. Mortar: 1 part Portland cement, 1/4 part hydrated lime, 3-3/4 parts mortar sand (max), water.
  8. Grout: 1 part Portland cement, 3 parts mortar sand, water.
- B. Steel Plate and Bar, Channels, Angles, M and S shapes: ASTM A 36.
- C. Welding Electrodes: Comply with AWS requirements.

## PART 3 EXECUTION

### 3.1 STONE CHECK DAM

- A. Construction
1. Immediately following ditch excavation, install stone check dams where indicated on the drawings.
  2. Ditch bottom shall be firm, unyielding, and free of loose sediment.
  3. Place NCDOT Class B riprap in ditch from top of bank to top of bank, sloping at 2:1 upstream and downstream. Provide a 6" depression in the riprap at the center point of the ditch.
  4. Line the upstream edge of the stone check dam with a 12" thick layer of NCDOT #5 or #57 stone from the bottom of the ditch to the top of the riprap.
- B. Maintenance
1. Inspect stone check dams immediately following all rainfall events.
  2. Remove sediment buildup from front of check dam when sediment height reaches one third (1/3) the height of the dam.
  3. If the stone becomes matted with soil material to the extent that the drainage through the stone deteriorates, the contaminated stone shall be removed from the site to an approved location and replaced with new stone at no cost to the Owner.
  4. Maintain stone check dams until County Engineering Department approves the surrounding vegetation establishment.

### 3.2 TEMPORARY GRAVEL CONSTRUCTION ENTRANCE

- A. Purpose
1. The purpose of the temporary gravel construction entrance pad is to clean the tires of vehicles exiting the site and prevent or limit the amount of soils tracked off-site on the paved roads.
- B. Construction

1. Verify location of temporary gravel construction entrance as shown on the drawings and determine if location will serve planned operations.
2. Size: 50' length minimum x 20' wide minimum. Contractor may need to increase size based upon volume of construction traffic and size of construction vehicles.
3. Provide turnout radii of 5' minimum, 20' preferred.
4. Strip topsoil and all vegetation. Excavate a minimum of 8" below existing paved roadway.
5. Proof roll subgrade. If subgrade is yielding, notify County Engineering Department prior to additional excavation.
6. Place 6" minimum thickness of NCDOT #5 or #57 washed stone in excavated area.

C. Maintenance:

1. Maintain entrance pad for the remainder of the Contract time. If the stone becomes matted with soil material to the extent that the performance of the gravel construction entrance deteriorates, the contaminated stone shall be excavated, removed from the site to an approved location, and replaced with new stone at no cost to the Owner.
2. Any material that is tracked onto the roadway shall be removed immediately. Sweeping the tracked material into the road shoulder or ditch is not acceptable.

### 3.3 SILT FENCE

A. Construction

1. Steel posts shall be used. Wooden stakes are not acceptable.
2. Posts shall be 5' in height and be of the self-fastener angle type.
3. Post spacing shall be 8' on center when used with a wire mesh fencing and standard strength filter fabric.
4. Post spacing of 6' on center may be used without wire mesh fencing provided extra strength fabric is used.
5. Maximum fabric height is 24" above existing grade.
6. Wire mesh fence and fabric shall be installed on the upslope side of the fence.
7. Filter fabric and wire fence mesh shall be secured to the steel post utilizing plastic or wire ties no more than 12" apart. Plastic or wire ties shall have a minimum 50 pound tensile strength.
8. Lap all fabric joints 4' minimum.
9. Excavate a trench 4" wide x 8" deep along the upslope side of the fence and place 12" of fabric in the excavated area. Backfill the excavation with the soil placed over the filter fabric. Compact the soil.

B. Maintenance

1. Inspect silt fence immediately following all rainfall events.
2. Remove sediment build up along fence.
3. Repair and replace silt fence as necessary.
4. Maintain silt fence throughout the Contract time.

### 3.4 ROCK ENERGY DISSIPATER

- A. Excavate to the indicated depth of rock lining or nominal placement thickness as follows. Remove loose, unsuitable material below bottom of rock lining, then replace with suitable material. Thoroughly compact and finish entire foundation area to firm, even surface.
- B. Lay and overlay geotextile fabric over substrate. Lay fabric parallel to flow from upstream to downstream. Overlap edges upstream over downstream. Provide a minimum overlap of 3 feet. Offset adjacent roll ends a minimum of 5 feet when lapped. Cover fabric as soon as possible and in no case leave fabric exposed more than 1 week.
- C. Carefully place rock on geotextile fabric to produce an even distribution of pieces, minimize the number of voids, and prevent tearing of the fabric.
- D. Unless indicated otherwise, place full course thickness in one operation to prevent segregation and to avoid displacement of underlying material. Arrange individual rocks for uniform distribution.

### 3.5 BLOCK AND GRAVEL DROP INLET PROTECTION

- A. Construction:
  - 1. Construct block and gravel drop inlet protection in accordance with drawings and details.
  - 2. Lay 2 rows of 8" hollow CMU's in a running bond around the drop inlet.
  - 3. Lower edge of CMU shall be 1-2" below the top of the grate frame to prevent lateral slippage of the blocks towards the center of the drop inlet.
  - 4. Two 8" CMUs on the first course shall be laid on their side to allow the passage of water.
  - 5. Fit hardware cloth with 1/2" opening over the sideways laid CMUs to retain stone. Edges of hardware cloth shall extend 6" past edges of sideways laid CMUs in all directions.
  - 6. Place clean NCDOT #5 or #57 stone around the outside of the CMUs to a height of 12-14" and slope away from the drop inlet at a 2:1 slope on all sides.
- B. Maintenance:
  - 1. Inspect drop inlets immediately following all rainfall events.
  - 2. Remove sediment buildup around the stone.
  - 3. If the stone becomes matted with soil material to the extent that the drainage through the stone deteriorates, the contaminated stone shall be removed from the site to an approved location and replaced with new stone at no cost to the Owner.
  - 4. Maintain drop inlet protection until final paving or until County Engineering Department approves the surrounding vegetation establishment.

### 3.6 ROCK PIPE INLET PROTECTION

#### A. Construction:

1. Clear the area of all debris that might hinder excavation and disposal of spoil.
2. Install the Class B or Class I riprap in a semi-circle around the pipe inlet. The stone should be built up higher on each end where it ties into the embankment. The minimum crest width of the riprap should be 3 feet, with a minimum bottom width of 11 feet. The minimum height should be 2 feet, but also 1 foot lower than the shoulder of the embankment or diversions.
3. A 1 foot thick layer of NC DOT #5 or #57 stone should be placed on the outside slope of the riprap.
4. The sediment storage area should be excavated around the outside of the stone horseshoe 18 inches below natural grade.
5. When the contributing drainage area has been stabilized, fill depression and establish final grading elevations, compact area properly, and stabilize with ground cover.

#### B. Maintenance

1. Inspect rock pipe inlet protection at least weekly and after each significant (1/2 inch or greater) rainfall.
2. Remove sediment and restore the sediment storage area to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap.
3. Place the sediment that is removed in the designated disposal area and replace the contaminated part of the gravel facing.
4. Check the structure for damage. Any riprap displaced from the stone horseshoe must be replaced immediately.
5. After all the sediment-producing areas have been permanently stabilized, remove the structure and all the unstable sediment. Smooth the area to blend with the adjoining areas and provide permanent ground cover.

### 3.7 RIPRAP CHANNEL LINING

- A. Excavate ditches in accordance with Section 31 00 00 Earthwork and to the lines and grade on the drawings and details.
- B. Where ditch bottoms and side slopes are to be lined with riprap, over-excavate the ditch bottom and sides to receive the geotextile fabric and the riprap. Over-excavation shall be done such that the finished grade of the top of the riprap is 2 inches below the proposed invert of the ditch.
- C. Lay and overlay geotextile fabric over substrate. Lay fabric parallel to flow from upstream to downstream. Overlap edges upstream over downstream. Provide a minimum overlap of 3 feet. Offset adjacent roll ends a minimum of 5 feet when lapped. Cover fabric as soon as possible and in no case leave fabric exposed more than 1 week.

- D. Carefully place rock on geotextile fabric to produce an even distribution of pieces, minimize the number of voids, and prevent tearing of the fabric.
- E. Unless indicated otherwise, place full course thickness in one operation to prevent segregation and to avoid displacement of underlying material. Arrange individual rocks for uniform distribution.

### 3.8 SITE STABILIZATION

- A. Incorporate erosion control devices indicated on the Drawings into the Project at the earliest practicable time.
- B. Construct, stabilize, and activate erosion controls before site disturbance within tributary areas of those controls.
- C. Stockpile and waste pile heights shall not exceed 15 feet. Slope stockpile sides at 2:1 or flatter. Cover to prevent windblown dust.
- D. Stabilize any disturbed area of affected erosion control devices on which activity has ceased and which will remain exposed for more than 20 days.
  - 1. During non-germinating periods, apply mulch at recommended rates.
  - 2. Stabilize disturbed areas which are either at finished grade or will not be disturbed within one year in accordance with Section 32 92 19 Seeding.
- E. Stabilize ditch excavations and stockpiles immediately.

### 3.9 FIELD QUALITY CONTROL

- A. Inspect erosion control devices on a weekly basis and after each runoff event. Make necessary repairs to ensure erosion and sediment controls are in good working order.

### 3.10 CLEANING

- A. When sediment accumulation in sedimentation structures has reached one-third depth of sediment structure or device, remove and dispose of sediment.
- B. Final inspection of the storm water detention pond will require removal of all accumulated sediment from the forebay and main basin prior to final acceptance. Depth of both shall be returned to design inverts.
- C. Do not damage structure or device during cleaning operations.
- D. Do not permit sediment to erode into construction areas, site areas, or natural waterways.

END OF EROSION CONTROLS

## **SECTION 321123 - AGGREGATE BASE COURSES**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Aggregate base course.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Aggregate Base Course:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment: Includes supplying and stockpiling material, scarifying substrate surface, placing where required, compacting, and fine grading as necessary to ready surface for asphalt placement.

#### **1.4 REFERENCES**

- A. American Association of State Highway and Transportation Officials:
- B. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- C. AASHTO M 147 – Standard Specifications for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses; American Association of State Highway and Transportation Officials; 1965 (2000).
- D. ASTM C 136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates; 2001.
- E. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).

- F. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
- G. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
- H. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
- I. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- J. ASTM D2940 - Standard Specification for Graded Aggregate Material For Bases or Subbases for Highways or Airports.
- K. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

## 1.5 SUBMITTALS

- A. Materials Source: Contractor shall identify the material source of aggregate to be used throughout the project. Material source shall not change without approval of the Engineer.
- B. Certification of Aggregate: Contractor shall submit documentation, from a materials testing lab stating that the material supplier has tested their aggregate product and the aggregate is in compliance with NCDOT "Standard Specifications for Roads and Structures", latest edition, for the gradation required.

## PART 2 PRODUCTS

### 2.1 AGGREGATE MATERIALS

- A. The material for aggregate base course shall conform to the requirements of NCDOT "Standard Specifications for Roads and Structures", January 2018 Edition, Section 1010-1, Aggregate for Non-Asphalt Type Base. Gradation shall be ABC according to NCDOT Section 1005.

## PART 3 EXECUTION

### 3.1 EXAMINATION AND PREPARATION

- A. Verify compacted substrate is dry.

- B. Verify that subgrade inspection has been completed in accordance with 312000 - Earthwork Section 3.8.
- C. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- D. Do not place fill on soft, muddy, or frozen surfaces.

### 3.2 AGGREGATE PLACEMENT

- A. Spread aggregate over prepared substrate in accordance with Section 520 of the NCDOT "Standard Specifications for Roads and Structures", January 2012 Edition.
- B. Place aggregate in layers of equal thickness to total compacted thickness as indicated on the drawings and details.
- C. The use of spreader boxes or other approved equipment is encouraged to reduce the segregation of the aggregate.
- D. Where the required compacted thickness of the base is 10" or less, the base material may be placed and compacted in one layer.
- E. Where the required compacted thickness is more than 10", spread the base material and compact in 2 or more equal lifts. In no case shall the minimum thickness of any one lift be less than 4".
- F. Level and contour surfaces to elevations, profiles, and gradients indicated.
- G. When using a conventional ring density test, the stone base shall be compacted to 100% of the maximum density obtainable with the Modified Proctor Test (AASHTO-T180) by rolling with ring or tamping roller or with a pneumatic tired roller with a minimum weight of ten tons.
- H. When using nuclear testing, adhere to the requirements of NCDOT Section 520-9. Provide a density for the aggregate base course of at least 98% of the target nuclear density, with no single test location less than 95% target nuclear density.
- I. When completed, the base course shall be smooth, hard, dense, unyielding, well-bonded, and ready for asphalt placement.

### 3.3 TOLERANCES

- A. Thickness tolerance: Provide the compacted thicknesses shown on the Drawings within a tolerance of minus 1/2".
  - 1. Depth measurements will be made by digging through the base at intervals no closer than 250', nor greater than 500' apart.

2. Where thickness is less than depth specified minus 1/2", it shall be corrected as directed by the Engineer.
- B. Variation From Design Elevation: Within 3/8" (9.5 mm) in 10', parallel to the center line of the roadway nor more than 1/2" from a template conforming to the cross-sections illustrated on the drawings and details.
- C. Deviations: Correct by removing materials, replacing with new materials, and reworking or re-compacting as required.

### 3.4 FIELD QUALITY CONTROL

- A. Compaction density testing will be performed on compacted aggregate base course in accordance with ASTM D1556.C.
- B. Results will be evaluated in relation to compaction curve determined by testing un-compacted material in accordance with ASTM D 698 ("standard Proctor").
- C. If tests indicate work does not meet specified requirements, then remove work, replace, and retest.
- D. Frequency of Tests: one (1) per parking lot area or one (1) per 500 linear foot of roadway.

END OF AGGREGATE BASE COURSES

## **SECTION 321216 - ASPHALT PAVING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.

#### **1.2 SUMMARY**

- A. This Section includes provisions for hot-mixed asphalt paving over prepared subbase.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Asphalt Pavement Mix (Base Course): B 25.0C
  - 1. Basis of Measurement: Lump Sum.
- B. Asphalt Pavement Mix (Binder Course): I 19.0C
  - 1. Basis of Measurement: Lump Sum.
- C. Asphalt Pavement Mix (Wearing Course or Surface Course): SF 9.5B
  - 1. Basis of Measurement: Lump Sum.
- D. Asphalt Pavement Mix (Wearing Course or Surface Course): SF 9.5C
  - 1. Basis of Measurement: Lump Sum.
- E. Tack Coat: Payment for tack coat, if required, shall be included in the base price per ton of asphalt paving requiring the use of the tack coat.
- F. Asphalt cement and any non-strip additive will be included in the base price per ton of asphalt paving.

#### **1.4 SUBMITTALS**

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:

1. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements of NCDOT "Standard Specifications for Roads and Structures".
2. Certification by NCDOT for approval of each pavement mix proposed for the project.

## 1.5 SITE CONDITIONS

- A. Weather Limitations: Apply prime and tack coats when ambient temperature is above 50 deg F and when temperature has not been below 35 deg F for 12 hours immediately prior to application. Do not apply when base is wet or contains an excess of moisture.
- B. Construct hot-mixed asphalt surface course when atmospheric temperature is above 50 deg F and when base is dry. Base course may be placed when air temperature is above 30 deg F and rising.
- C. Grade Control: Establish and maintain required lines and elevations.

## 1.6 QUALITY ASSURANCE

- A. All materials, construction methods and testing shall comply with the requirements of the latest editions of the North Carolina Department of Transportation (NCDOT) "Standard Specifications for Roads and Structures" and the Asphalt Handbook Manual Series No. 4 (MS-4).
- B. All work within any NCDOT right-of-way shall conform to the provisions and conditions of the NCDOT encroachment agreement(s) and driveway permit(s) and other applicable NCDOT standards and policies. The encroachment agreement(s) and driveway permit(s) are considered part of the project specifications by reference. Copies of the agreement(s) and permit(s) will be provided upon request from the Engineer.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. General: Use locally available materials and gradations that comply with the requirements of the NCDOT "Standard Specifications for Roads and Structures" and exhibit a satisfactory record of previous installations. All asphalt mixes shall include at least 20% recycled asphalt product.
- B. Aggregate Base Course (ABC): Aggregate base course meeting the requirements of the latest version of NCDOT "Standard Specifications for Roads and Structures" Section 1010 – Aggregate for Non-asphalt Type Bases.

- C. Superpave Asphalt Paving Mix: Superpave base, intermediate and surface asphalt paving mix meeting the requirements of the latest version of NCDOT "Standard Specifications for Roads and Structures." Types as indicated on the drawings.
- D. Tack Coat: Asphalt material meeting the requirement of the latest version of NCDOT "Standard Specifications for Roads and Structures."

## PART 3 - EXECUTION

### 3.1 SURFACE PREPARATION

- A. General: Remove loose material from compacted subbase surface immediately before applying prime coat.
- B. Proof-roll prepared subgrade surface as described in Division 31 Section "Earthwork" to check for unstable areas and areas requiring additional compaction.
- C. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving. Ensure subgrade is graded for proper drainage. Repair as needed to avoid ponding on final pavement surfaces.
- D. Tack Coat: Apply to contact surfaces of previously constructed asphalt or Portland cement concrete and surfaces abutting or projecting into hot-mixed asphalt pavement. Distribute at a rate of 0.05 to 0.15 gallons per sq. yd. of surface.
- E. Allow to dry until at proper condition to receive paving.
- F. Exercise care in applying bituminous materials to avoid smearing of adjoining concrete surfaces. Remove and clean damaged surfaces.
- G. Place aggregate base courses as specified in Section 31 20 00 "Earthwork".

### 3.2 PLACING MIX

- A. Limitations: Do not produce or place asphalt mixtures during rainy weather, when the subgrade or base course is frozen, or when the moisture on the surface to be paved would prevent proper bond. Comply with all NCDOT weather and temperature limitations.
- B. General: Place hot-mixed asphalt mixture on prepared surface, spread, and strike off. Spread mixture at minimum temperature of 225 deg F. Place areas inaccessible to equipment by hand. Place each course to required grade, cross-section, and compacted thickness.
- C. Paver Placing: Place in strips not less than 10 feet wide, unless otherwise acceptable to Engineer. After first strip has been placed and rolled, place succeeding strips and

extend rolling to overlap previous strips. Complete base course for a section before placing surface course.

- D. Immediately correct surface irregularities in finish course behind paver. Remove excess material forming high spots with shovel or lute.
- E. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of hot-mixed asphalt course. Clean contact surfaces and apply tack coat.

### 3.3 ROLLING

- A. General: Begin rolling when mixture will bear roller weight without excessive displacement.
- B. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.
- C. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling and repair displaced areas by loosening and filling, if required, with hot material.
- D. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been evenly compacted.
- E. Finish Rolling: Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained required density. Compact the asphalt to at least the minimum percentage of the maximum specific gravity listed below unless otherwise allowed by NCDOT.
  - 1. S-9.5B, I-19.0C, B-25.0C: 92.0% of Maximum Specific Gravity.
- F. Patching:
  - 1. Saw cut perimeter of area to be patched and excavate existing pavement section to solid sub-grade.
  - 2. Install new base material with the type and thickness of base material indicated on the drawings and details.
  - 3. Tack coat all edges of excavation and existing pavement.
  - 4. Patch with type and thickness of wearing coarse material as indicated on the drawings and details.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

### 3.4 FIELD QUALITY CONTROL

- A. General: Testing of asphalt concrete mix and in-place hot-mixed asphalt courses for compliance with requirements for thickness and surface smoothness will be done by Owner's testing laboratory in accordance with Division 01 Section "Quality Control." Repair or remove and replace unacceptable paving as directed by Engineer.
  - 1. Testing agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from the specified requirements.
- B. Thickness: In-place compacted thickness shall be tested in accordance with ASTM D 3549. Results shall be considered unacceptable if less than the thickness specified on the drawings.
- C. Surface Smoothness: Test finished surface of each hot-mixed asphalt course for smoothness, using 10 feet straightedge applied parallel with and at right angles to centerline of paved area. Surfaces will not be acceptable if exceeding the following tolerances for smoothness:
  - 1. Base Course Surface: 1/4 inch.
  - 2. Wearing Course Surface: 3/16 inch.
  - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
  - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
  - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
    - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
    - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- E. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.
- F. Contractor shall repair all test core holes with full depth asphalt patch.
- G. Perform ponding water tests. Repair areas of pavement that pond water.
- H. Check surface areas at intervals as directed by Engineer.

END OF ASPHALT PAVING

## **SECTION 321313 - SITE CONCRETE**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.

#### **1.2 DESCRIPTION OF WORK:**

- A. Extent of Portland cement concrete paving is shown on drawings, including:

- 1. Curbs and gutters
- 2. Walkways

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Concrete Sidewalks:

- 1. Basis of Measurement: Lump Sum
- 2. Basis of Payment: Includes forms, reinforcing, concrete, accessories, placing, finishing, curing, and testing.

- B. Concrete Curb and Gutter:

- 1. Basis of Measurement: Lump Sum
- 2. Basis of Payment: Includes forms, concrete, accessories, placing, finishing, and curing.

#### **1.4 REFERENCES**

- A. American Concrete Institute:

- 1. ACI 301 - Specifications for Structural Concrete.
- 2. ACI 304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete.

- B. American Society for Testing and Materials

- 1. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
- 2. ASTM C33 - Standard Specification for Concrete Aggregates.
- 3. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

4. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
5. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
6. ASTM C150 - Standard Specification for Portland Cement.

## 1.5 SUBMITTALS

- A. Provide certification that all materials meet NCDOT standards for the class of concrete required.
- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Engineer.
- C. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Laboratory test reports for evaluation of concrete materials and mix design tests.
- E. Testing Agency: A testing laboratory will be retained by the Owner to perform material evaluation tests as required by these specifications.

## 1.6 QUALITY ASSURANCE

- A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
  1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings".
  2. ACI 318, "Building Code Requirements for Reinforced Concrete".
  3. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice".
- B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C94 requirements for production facilities and equipment.

## 1.7 ENVIRONMENTAL REQUIREMENTS

- A. Do not place concrete when base surface temperature is less than 40 degrees F or surface is wet or frozen.

## 1.8 JOB CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Forms: Steel, wood, or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal. Use straight forms, free of distortion and defects.
  - 1. Use flexible spring steel forms or laminated boards to form radius bends as required.
  - 2. Coat forms with a nonstaining form release agent that will not discolor or deface surface of concrete.
- B. Welded Wire Mesh: Welded plain cold-drawn steel wire fabric, ASTM A 185.
- C. Reinforcing Steel: ASTM A 615, Grade 60, deformed
- D. Concrete Materials: Comply with requirements of applicable Division 3 sections for concrete materials, admixtures, bonding materials, curing materials, and others as required.
- E. Expansion Joint Materials: Comply with requirements of applicable Division 7 sections for preformed expansion joint fillers and sealers.
- F. Antispalling Compound: Combination of boiled linseed oil and mineral spirits, complying with AASHTO M-233.
- G. Liquid-Membrane Forming and Sealing Curing Compound: Comply with NCDOT Standard Specifications for Roads and Structures.

### 2.2 CONCRETE MIX, DESIGN, AND TESTING

- A. Comply with requirements of applicable Division 3 sections for concrete mix design, sampling and testing, and quality control or NCDOT Standard Specifications for Roads and Structures whichever is more stringent.
- B. Design mix to produce normal-weight concrete consisting of Portland cement, aggregate, water-reducing or high-range water-reducing admixture (superplasticizer), air-entraining admixture, and water to produce the following properties:
  - 1. Comply with the requirements of NCDOT Standard Specifications for Roads and Structures, unless otherwise indicated.

## PART 3 - EXECUTION

### 3.1 SURFACE PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete
- B. Verify elevations of based material are correct.
- C. Proof-roll prepared subbase surface to check for unstable areas and need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving.

### 3.2 FORM CONSTRUCTION

- A. Set forms to required grades and lines, braced and secured. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement.
- B. Check completed formwork for grade and alignment to following tolerances:
  - 1. Top of forms not more than 1/8 inch in 10 feet.
  - 2. Vertical face on longitudinal axis, not more than 1/4 inches in 10 feet.
- C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

### 3.3 REINFORCEMENT

- A. Locate, place and support reinforcement as specified in Division 3 sections, unless otherwise indicated.

### 3.4 CONCRETE PLACEMENT

- A. General: Comply with requirements of applicable Division 3 sections for mixing and placing concrete or NCDOT Standard Specifications for Roads and Structures whichever is more stringent.
- B. Do not place concrete until subbase and forms have been checked for line and grade. Moisten subbase if required to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- C. Place concrete by methods that prevent segregation of mix. Consolidate concrete along face of forms and adjacent to transverse joints with internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocation of reinforcing, dowels, and joint devices.

- D. Deposit and spread concrete in a continuous operation between transverse joints as far as possible. If interrupted for more than 1/2 hour, place a construction joint.
- E. Fabricated Bar Mats: Keep mats clean and free from excessive rust, and handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities or replace units as required before placement. Set mats for a minimum 2-inch overlap to adjacent mats.
- F. Place concrete in 2 operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
- G. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer or use bonding agent if acceptable to Engineer.
- H. Curbs and Gutters: Automatic machine may be used for curb and gutter placement. If machine placement is to be used, submit revised mix design and laboratory test results that meet or exceed minimums indicated. Machine placement must produce curbs and gutters to required cross-section, lines, grades, finish, and jointing as indicated for formed concrete. If results are not acceptable, remove and replace with formed concrete meeting requirements.
- I. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- J. Cold-Weather Placement: Comply with provisions of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
  - 1. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
  - 2. Do not use frozen materials or materials containing ice and snow. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
- K. Hot-Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.
  - 1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F (32 deg C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
  - 2. Cover welded wire fabric with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.

3. Fog spray forms, welded wire fabric, and aggregate base course just before placing concrete. Keep aggregate base course moisture uniform without standing water, soft spots, or dry areas.

### 3.5 JOINTS

- A. General: Construct expansion, weakened-plane (contraction), and construction joints true to line with face perpendicular to surface of concrete. Construct transverse joints at right angles to the centerline, unless otherwise indicated.
- B. Weakened-Plane (Contraction) Joints: Provide weakened-plane (contraction) joints, sectioning concrete into areas as shown on drawings. For sidewalks, tooled or sawed joints shall be provided at regular intervals of not less than 4 feet and not more than 6 feet along the length of the sidewalk. Construct weakened-plane joints for a depth equal to at least 1/4 concrete thickness, as follows:
  1. Tooled Joints: Form weakened-plane joints in fresh concrete by grooving top portion with a recommended cutting tool and finishing edges with a jointer.
  2. Sawed Joints: Form weakened-plane joints with powered saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into hardened concrete as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.
  3. Inserts: Use embedded strips of metal or sealed wood to form weakened-plane joints. Set strips into plastic concrete and carefully remove strips after concrete has hardened.
- C. Construction Joints: Place construction joints at end of placements and at locations where placement operations are stopped for more than 1/2 hour, except where such placements terminate at expansion joints.
  1. Construct joints as indicated or, if not indicated, use standard metal keyway-section forms.
- D. Expansion Joints: Provide premolded joint filler for expansion joints abutting concrete curbs, catch basins, manholes, inlets, structures, walks, and other fixed objects, unless otherwise indicated.
- E. Locate expansion joints at 30 feet o.c. for each pavement lane unless otherwise indicated. Joints in adjacent curb, gutter and sidewalk joints shall be aligned.
- F. Extend joint fillers full width and depth of joint, not less than 1/2 inch or more than 1 inch below finished surface where joint sealer is indicated. If no joint sealer, place top of joint filler flush with finished concrete surface.
- G. Provide joint fillers in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.
- H. Protect top edge of joint filler during concrete placement with a metal cap or other temporary material. Remove protection after concrete has been placed on both sides of joint.

- I. Fillers and Sealants: Comply with requirements of applicable Division 7 sections for preparation of joints, materials, installation, and performance.

### 3.6 CONCRETE FINISHING

- A. After striking-off and consolidating concrete, smooth surface by screeding and floating. Use hand methods only where mechanical floating is not possible. Adjust floating to compact surface and produce uniform texture.
- B. After floating, test surface for trueness with a 10-ft. straightedge. Distribute concrete as required to remove surface irregularities and refloat repaired areas to provide a continuous smooth finish.
- C. Work edges of slabs, gutters, back top edge of curb, and formed joints with an edging tool, and round to 1/4-inch radius, unless otherwise indicated. Eliminate tool marks on concrete surface.
- D. After completion of floating and when excess moisture or surface sheen has disappeared, complete troweling and finish surface as follows:
  1. Broom finish by drawing a fine-hair broom across concrete surface perpendicular to line of traffic. Repeat operation if required to provide a fine line texture acceptable to Engineer.
  2. Exposed-Aggregate Finish: Provide exposed aggregate finish, where shown on plans, by applying an approved retardant curing compound to the surface. Allow minimum 12 hours of setting time before washing surface to expose a maximum of (1/3) one-third of stone surface. Aggregate shall be brown Riverstone having a uniform size and color for each subsequent concrete pour. Aggregate size shall range between 1/2" and 3/4".
  3. Provide a smooth rubbed finish for exposed formed concrete surfaces and surfaces that are to be covered with a coating or covering material applied directly to concrete. Remove fins and projects, patch defective areas with cement grout, and rub smooth.
- E. Do not remove forms for 24 hours after concrete has been placed. After form removal, clean ends of joints and point-up any minor honeycombed areas. Remove and replace areas or sections with major defects, as directed by Engineer.

### 3.7 CURING

- A. Protect and cure finished concrete paving in compliance with applicable requirements of Division 3 sections. Use membrane-forming curing and sealing compound or approved moist-curing methods.

### 3.8 FIELD QUALITY CONTROL

- A. Owner will employ a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include the following:

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
    - a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
    - b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test but no less than one test for each day's pour of each type of air-entrained concrete.
    - c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
    - d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.
    - e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. but less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
  2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
  3. When total quantity of a given class of concrete is less than 50 cu. yd., Engineer may waive strength testing if adequate evidence of satisfactory strength is provided.
  4. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
  5. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi.
- B. Test results will be reported in writing to Engineer, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests.
- C. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
- D. Additional Tests: The testing agency will make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Engineer. Testing agency may conduct tests to determine

adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

### 3.9 REPAIRS AND PROTECTIONS

- A. Repair or replace cracked, broken or defective concrete curbs and curb and gutter, as directed by Engineer.
- B. Replace cracked, broken or defective concrete sidewalks.
- C. Repair or replace cracked, broken or defective concrete pavement, as directed by Engineer.
- D. Drill test cores where directed by Engineer when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to pavement with epoxy adhesive.
- E. Protect concrete from damage until acceptance of work. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- F. Sweep concrete pavement and wash free of stains, discolorations, dirt, and other foreign material just before final inspection.

END OF SITE CONCRETE

## **SECTION 321700 - PAVEMENT MARKINGS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, January 2018 Edition.

#### **1.2 SUMMARY**

- A. This Section includes, but is not limited to, the following:
  - 1. Establishing the location of pavement markings and applying pavement markings for parking space lines, traffic control, fire lane and accessible spaces.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Traffic Lines and Markings:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment: Includes furnishing and installing.
- B. Legends:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment: Includes furnishing and installing.

#### **1.4 QUALITY ASSURANCE**

- A. All work and materials shall conform to the requirements of the latest edition of the North Carolina Department of Transportation (NCDOT) Standard Specifications for Roads and Structures.
- B. Installer Qualifications: Engage an experienced installer, who has successfully completed striping and signage projects similar in size and complexity to this project. The installer's primary business (defined as a minimum of 60% of total billings) shall be striping and signage.

## 1.5 SUBMITTALS

A. Product Data and written confirmation that the following materials are included on NCDOT's list of approved construction materials:

1. Pavement marking paint
2. Glass beads

## PART 2 - PRODUCTS

### 2.1 PAVEMENT MARKING PAINT

A. Paint shall conform to the requirements of Division 12 of the (NCDOT) Standard Specifications for Roads and Structures and Federal Specification TTP-1952. Color shall be white unless otherwise indicated.

B. Curb painting color along fire lanes shall be yellow, unless otherwise indicated.

C. Glass Beads: AASHTO M247, Type 1, coated to enhance embedment and adherence with paint.

## PART 3 - EXECUTION

### 3.1 MAINTENANCE OF TRAFFIC

A. Provide short term traffic control to prevent interference with marking operations and to prevent traffic on newly applied markings before markings dry.

B. Maintain access to existing businesses, residences, and other properties requiring access.

### 3.2 SURFACE PREPARATION FOR PAVEMENT MARKING

A. Apply painted pavement markings only when the ambient temperatures is above 40°F, unless otherwise approved. Apply thermoplastic pavement markings only when the ambient temperature is above 50°F

B. Allow pavement to cure for a period of not less than 7 days before applying pavement marking.

C. Clean surfaces thoroughly before application of paint. Remove, dust, dirt and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required.

D. Remove existing pavement markings, residual curing compounds and other coating adhering to the pavement with scrapers, wire brushes, water blasting, sandblasting or

mechanical abrasion as required. Areas of existing pavement affected by oil or grease shall be scrubbed with an approved chemical and rinsed thoroughly. Seal oil-soaked areas with shellac or primer after cleaning.

- E. Pavement surfaces shall be dry and clean prior to painting. Pavement markings shall not be applied within 24 hours following rain or other inclement weather or when rain is imminent.

### 3.3 APPLICATION OF PAVEMENT MARKING

- A. Apply paint in accordance with the requirements of Division 12 of the (NCDOT) Standard Specifications for Roads and Structures and manufacturer's recommendations.
- B. Lay out lines and markings to the width and length as indicated. All parking space lines shall be 4 inches wide.
- C. Apply paint with an approved paint applicator.
- D. Apply paint at manufacturer recommended rates to provide a minimum 15 mil wet thickness.

### 3.4 PROTECTION OF WORK

- A. Protect painted pavement markings from vehicular and pedestrian traffic until paint is dry and track free. Follow manufacturer's recommendations or use minimum of 30 minutes.

END OF PAVEMENT MARKINGS

## **SECTION 323113 - CHAIN-LINK FENCES AND GATES (GALVANIZED)**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 WORK INCLUDED**

- A. Galvanized steel chain link fence and gates.

#### **1.3 SUBMITTALS**

- A. Product Data: Submit manufacturer's technical data, and installation instruction for fencing, fabric, gates and accessories.
- B. Shop Drawings: Submit shop drawings indicating location of fence (with dimensions), height, post locations, details of post installation, gate sing, hardware and accessories.
- C. Samples: None required

#### **1.4 QUALITY ASSURANCE**

- A. Installer Qualifications: Engage an experienced installer who has completed chain-link fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Source Limitations for Chain-Link Fences and Gates: Obtain each color, grade, finish, type, and variety of component for chain-link fences and gates from one source with resources to provide chain-link fences and gates of consistent quality in appearance and physical properties.

#### **1.5 PROJECT CONDITIONS**

- A. Field Measurements: Verify layout information for chain-link fences and gates indicated in relation to property survey and existing structures. Verify dimensions by field measurements.

## PART 2 - PRODUCTS

### 2.1 GENERAL:

- A. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
  - 1. Galvanized Steel Fencing and Fabric:
    - a. Allied Tube and Conduit Corp.
    - b. American Chain Link Fence Company
    - c. American Tube Company
    - d. Anchor Fence, Inc.
    - e. Century Tube Corp.
    - f. Cyclone Fence Div./USX Corp.

### 2.2 FABRIC:

- A. Steel Fabric: Comply with Chain Link Fence Manufacturers Institute (CLMFI) Product Manual. Provide one-piece fabric widths. Wire size includes zinc coating.
- B. Size: 2-inch diamond mesh, 9-gauge (0.148-inch diameter) wire.
- C. Galvanized Steel Finish: ASTM A 392, Class I, with not less than 1.2 oz. zinc per sq. ft. of uncoated wire surface.
- D. Selvage:
  - 1. Selvage shall be twist and barbed at top and bottom.

### 2.3 FRAMING:

- A. Strength requirements for posts and rails shall conform to ASTM F 669.
- B. Pipe shall be straight, true to section, material and sizes specified.
- C. Steel Framework, General: Posts, rails, braces and gate frames.
  - 1. Type II Pipe: Manufactured from steel conforming to ASTM A 569 or A 446, grade D, cold formed, electric welded with minimum yield strength of 50,000 p.s.i. and triple coated with minimum 0.9 oz. Zinc per square foot after welding, a chromatic conversion coating and a clear polymer overcoat. Corrosion protection on inside surfaces shall protect the metal from corrosion when subjected to the salt spray test of ASTM B 117 for 300 hours with the end point of 5% Red Rust.
- D. End, Corner and Pull Posts:
  - 1. For fabric height up to 6' - 2.375" OD Type II steel pipe. (3.12 lb/ft).

2. For fabric height over 6' - 4" OD Type II steel pipe. (4.64 lb/ft).

E. Line Posts:

1. For fabric height up to 6' - 1.90" OD Type II steel pipe (2.28 lb/ft).
2. For fabric height over 6' - 4" OD Type II steel pipe (3.65 lb/ft).

F. Gate Posts:

1. Provide posts for supporting single gate leaf, or one leaf of a double gate installation, for nominal gate widths as follows:
  - a) 6' and Under: 2.875" OD Type II steel pipe (4.64lb/ft).
  - b) Over 6': 4.000" OD Type II steel pipe (8.65 lb/ft).

G. Top & Bottom Rail:

1. Manufacturer's longest lengths, with expansion-type couplings, approximately 6" long, for each joint. Provide means for attaching rail securely to each gate corner, pull, & end post.
  - a) Galvanized Steel: 1-1/4" NPS (1.66" OD) Type II steel pipe.

H. Intermediate and/or Center Rail:

1. Same material as top rail. Manufacturer's standard galvanized steel cap required for each end.

2.4 FITTINGS AND ACCESSORIES:

A. Material: Comply with ASTM F 626. Mill finished galvanized steel, to suit manufacturer's standards.

1. Zinc Coating: Unless specified otherwise, galvanize steel fence fittings and accessories in accordance with ASTM A 153, with zinc weights indicated.

B. Tension Wire: 7 gauge (0.177" diameter) metallic coated steel marcelled tension wire conforming to ASTM A 824 with finish to match fabric.

1. Type II Zinc Coated, Class 2, with a minimum coating weight of 1.2 oz. per sq. ft. of uncoated wire.

C. Wire Ties:

1. 9 gauge [0.148" (3.76mm)] galvanized steel wire for attachment of fabric to line posts.
2. Double wrap 13 gauge [0.092" (2.324mm)] for rails and braces.
3. Hog ring ties of 12-1/2 gauge [0.0985" (2.502mm)] for attachment of fabric to tension wire.

D. Post Brace Assembly:

1. Manufacturer's standard adjustable brace at end of gate posts and at both sides of corner and pull posts, with horizontal brace located at mid height of fabric. Provide same material as top rail for brace and truss to line posts with 0.375" diameter rod and adjustable tightener. Manufacturer's standard galvanized steel cap required for each end.

E. Post and Line Caps: Weathertight closure cap required for each post. If top rail is required, use line post caps with loop.

F. Tension or Stretcher Bars: Hot-dip galvanized steel with minimum length 2" less than full height of fabric, minimum cross section of 3/16" by 3/4" and minimum 1.2 oz. zinc coating per sq. ft. of surface area. One bar is required for each gate and end post and two for each corner and pull post, except where fabric is integrally woven into post.

G. Tension and Brace Bands: Minimum 3/4" wide hot-dip galvanized steel with minimum 1.2 oz. zinc coating per sq. ft. of surface area.

1. Tension bands: Minimum 14 gauge (0.074") thick.
2. Tension and Brace bands: Minimum 12 gauge (0.105") thick.

H. Barbed wire: Zinc -coated steel wire double-strand, 13-3/4 gauge, [0.083" (2.10mm)] twisted line wire with galvanized steel, 4 point barbs spaced approximately 3" (76.2 mm) on center.

I. Barbed wire supporting arms: Pressed steel arms with provisions for attaching 3 rows of barbed wire. Arms shall withstand 250 lb. (113.5 kg) downward pull at outermost end of arm without failure.

J. Provide 45°, 3 strands, single arm.

K. Provide intermediate arms with hole for passage of top rail.

L. Nuts and bolts shall be galvanized.

## 2.5 POST SETTING MATERIALS

A. Comply with the requirements for NCDOT Class A, 3000 psi concrete.

## 2.6 GATES:

A. Fabrication:

1. Fabricate perimeter frames of gates from metal and finish to match fence framework. Utilize fusion or stainless-steel welded connections to form a rigid one-piece unit. Assemble gate frames by welding, providing security against removal or breakage of connections. Provide horizontal and vertical members to ensure proper gate operation and attachment of fabric, hardware and

- accessories. Space frame members maximum of 8' apart unless otherwise indicated.
2. Provide same fabric as for fence. Install fabric with stretcher bars at vertical edges and at top and bottom edges. Attach stretcher hooks to gate frame at not more than 15" o.c. Install diagonal cross-bracing consisting of 3/8" diameter adjustable length truss rods on gates to ensure frame rigidity without sag or twist.
- B. Swing Gates: Comply with ASTM F 900.
1. Fabricate perimeter frames of minimum 1.90" OD Type II steel pipe.
- C. Gate Hardware: Provide hardware and accessories for each gate, galvanized per ASTM A 153, and in accordance with the following:
1. Hinges: Size and material to suit gate size, non-lift-off type, offset to permit 180 degrees gate opening. Provide 1-1/2 pair of hinges for each leaf over 6' nominal height.
  2. Latch: Forked type to permit operation from either side of gate, with padlock eye as integral part of latch.
  3. Keeper: Provide keeper that automatically engages gate leaf and holds it in open position until manually released.
  4. Double Gates: Provide gate stops for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Ensure plunger bar cannot be removed without tools. Include locking device and padlock eyes as integral part of latch, permitting both gate leaves to be locked with single padlock.
  5. Barbed wire top: Incorporate provisions for barbed extensions by extending vertical members 13" (380mm) to accommodate three strands of barbed wire.
  6. Hardware materials: hot dipped galvanized steel or malleable iron shapes to suit gate size.
  7. Gate posts: Steel pipe ASTM F1083 standard weight schedule 40 minimum yield strength of 25,000 PSI size as indicated. Hot dipped galvanized with minimum 1.8 oz/ft<sup>2</sup> of zinc.

## 2.7 CANTILEVER SLIDE GATES

- A. Cantilever Slide Gates: In compliance with ASTM F1184 Type II
1. Class 1-External Roller Design: Horizontal top and bottom steel pipe "track" members to be 2.375 in. OD. Vertical and internal members, 1.900 in. O.D. in compliance with ASTM F1083 schedule 40 galvanized steel pipe. Gate frame to be fabricated by welding, vertical and horizontal members installed no greater than 8 ft. apart. Welded joints are to be protected by applying zinc-rich paint in accordance with ASTM Practice A780. Gates designed to open or close by applying an initial pull force no greater 40 lbs.. Match chain link fabric to that of the fence system. Positive locking pressed steel latch, galvanized after fabrication. Galvanized steel drop bars provided with double gates. Gateposts, 4.000 in. OD schedule 40 pipe per ASTM F1083. Provide safety protective guards for the top and bottom external rollers following ASTM F1184 guidelines.

2. Class 2-Internal Roller Design: Gate frame fabricated by welding, vertical and horizontal members installed no greater than 8 ft. apart. Class 2 cantilever slide gates to comply with the performance deflection criteria listed in ASTM F1184. Gates designed to open or close by applying an initial pull force no greater than 40 lbs.. Internal truck assemblies designed to handle the forces required for gate size opening and height. Match chain link fabric to that of the fence system. Gateposts, 4.000 in. O.D. schedule 40 pipe per ASTM F1083.
  - a. Steel Pipe Frame Design: Match the specification of Class 1 cantilever slide gate. Securely bolt an extruded aluminum enclosed track to the top horizontal member that is designed to accommodate internal roller assemblies.
- B. Polymer coated horizontal slide gates and posts shall match the coating type and color as that specified for the fence framework.
- C. Electrically operated horizontal slide gates must be manufactured and installed to comply with the safety requirements of ASTM F2200 and UL 325

## 2.8 GATE OPERATORS

- A. Gate operators shall be SlideSmart DC 15with Smart DC controller by HySecurity or approved equal.
- B. Operation shall be by means of a brushed DC electric motor driving a single reduction gear reducer with an output sprocket driving #40 plated roller chain. When the gate is stopped, the motor applies a brake to the drive assembly which inhibits any forced, manual operation of the gate. Gate position is constantly monitored allowing for automatic reposition if motion is detected without the operator receiving a run command. The opening and closing speeds are user adjustable 0.75, 1.0, or 1.25 fps. The gear reducer shall be filled with synthetic lubricant capable of allowing operation down to -25°C (-13°F) without a heater. Operator shall be capable of handling gates up to 40ft (12m) in length and weighing up to 1,500lb (685kg).
- C. Gate Operator shall operate in the event of a power failure in an uninterruptible power supply mode utilizing battery power for a minimum of 4,000ft of gate travel.
- D. Standard mechanical components shall include as a minimum:
  1. Two piece linear low density polyethylene cover with top locking latch. Cover protects bystanders from pinch hazards of roller chain traveling through idlers and drive sprocket.
  2. Frame to be constructed of 10ga or greater steel plate, welded.
  3. Finish: Frame to be zinc plated. Other components zinc plated or non-corroding.
  4. Operator shall contain a position sensing device and a means of setting the limit position and maintaining this position in non-volatile memory. Operator must also contain a magnetic absolute position sensor to verify the gate position.
  5. Zinc or nickel plated #40 roller chain with chain mount brackets and connecting hardware.

- E. Minimum standard electrical components: Industrial grade.
  - 1. Motor: ½ HP brushed DC motor with ball bearings.
  - 2. Electronic circuit boards to be conformal coated to resist moisture induced failures.
  - 3. All components shall have overload protection.
  - 4. Controls: Smart Controller Board containing:
    - a. Adaptive inherent entrapment sensor;
    - b. built in “warn before operate” system;
    - c. built in timer to close;
    - d. anti-tailgate mode;
    - e. built-in multi-level power surge and lightning strike protection;
    - f. battery charging
    - g. Pulse width modulated control of motor using 110 Amp rated solid state switching devices.
  - 5. Input Power: 208V.
- F. Stop switch, accessible from outside.
- G. Back Drivable: During AC and DC power loss, the gate can be pushed open.
- H. Required external sensors: Provide photo eyes or gate edges or a combination thereof to be installed such that the gate is capable of reversing in either direction upon sensing an obstruction.
- I. Control devices:
  - 1. Entry gate shall be controlled by card reader and remotely from station located inside the building.
  - 2. Exit gate shall be controlled by vehicle detector loop.

### PART 3 – EXECUTION

#### 3.1 INSTALLATION:

- A. General: Install fence in compliance with ASTM F 567 and manufacturers recommendations. Do not begin installation and erection before final grading is completed, unless otherwise permitted. Apply fabric to outside of framework, unless otherwise indicated.
- B. Locate terminal post at each fence termination and change in horizontal or vertical direction of 30° or more, or as indicated on plans.
- C. Excavation:
  - 1. Drill or hand excavate (using post hole digger) holes for posts to diameters and spacing indicated, in firm, undisturbed or compacted soil.

2. Holes in asphalt or concrete surfaces will be cut by core-drilling with a bit of diameter at least equal to the required hole diameter. Holes in concrete may be formed prior to placing concrete.
3. Excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than 4 times largest cross-section of post.
4. Excavate hole to depths approximately 6" lower than post bottom, with bottom of posts set not less than 36" below finish grade surface.

D. Setting Posts:

1. Space 10' o.c. maximum, unless otherwise indicated.
2. Center and align posts in hole, 6" above bottom of excavation.
3. Protect portions of concrete posts above ground from concrete splatter. Place concrete around post and vibrate or tamp for consolidation. Check each post for vertical and top alignment and hold in position during placement and finishing operations.
4. Extend concrete above grade and slope all around (dome) to allow for drainage away from post. Uniformly and neatly texture the concrete surface with a broom finish. Remove any spilled or splashed concrete from the post and surrounding area immediately.

E. Top Rails:

1. Run rail continuously through line post caps, bending to radius for curved runs and at other posts terminating into rail end attached to posts or post caps fabricated to receive rail. Provide expansion couplings as recommended by fencing manufacturer.

F. Center Rails:

1. Install in one place between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary. Install center rails on fence 12' or taller, or as indicated on plans.

G. Bottom Rails:

1. Install in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings when necessary.

H. Brace Assemblies:

1. Install braces so posts are plumb when diagonal rod is under proper tension.

I. Top and Bottom Tension Wire:

1. Install tension wires through post cap loops before stretching fabric and tie to each post cap with not less than same gauge and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire, using 11 - ga. galvanized steel hog rings spaced maximum 24" o.c. Install where top and bottom rails are not specified on plans.

J. Fabric:

1. Leave approximately 2" between finish grade and bottom selvage. Pull fabric taut and tie to posts, rails and tension wires. Attach fabric with wire ties to line posts at 12"-15" (381mm) o.c. and to rails, braces, and tension wire at 24" (600 mm) o.c. Install fabric on security side of fence, unless otherwise indicated, and anchor to framework so that fabric remains in tension after pulling force is released.
2. For athletic field fencing, install fabric on the field side of the fence unless otherwise indicated.

K. Stretcher Bars:

1. Thread through fabric 4" o.c., and secure to end, corner, pull and gate posts with tension bands spaced maximum 15" o.c.

L. Accessories:

1. Tie Wires: Use U-shaped wire, conforming to diameter of pipe to which attached, clasp pipe and fabric firmly with ends twisted at least 2 full turns. Bend ends of wire to minimize hazard to persons or clothing.
2. Fasteners: Install nuts on side of fence opposite fabric side for added security.
3. Barbed Wire: Uniformly space parallel rows of barged wire on security side of fence. Pull wire taut and attach in clips or slots of each extension.

M. Fasteners:

1. Install nuts for tension bands and hardware bolts on site of fence opposite fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

N. Gates:

1. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

### 3.2 FINISHING

- A. Remove and replace sections of damaged fence and fittings. Minor aesthetic damage may be touched up with a suitable spray on material.
- B. Clean up debris and unused material and remove from the site.

END OF CHAIN LINK FENCES AND GATES (GALVANIZED)

## **SECTION 329200 – LAWNS AND GRASSES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Erosion and Sediment Control Planning and Design Manual.

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Fine grading and preparing lawn areas (including courtyards)
  - 2. Topsoil Placement
  - 3. Soil Amendments
  - 4. Fertilizers
  - 5. Seeding
  - 6. Hydroseeding

#### **1.3 DEFINITIONS**

- A. Finish Grade: Elevation of finished surface of planting soil.

#### **1.4 SUBMITTALS**

- A. Certification by product manufacturer that the following products supplied comply with requirements:
  - 1. Grass Seed
    - a. Certification of grass seed from seed vendor for each grass-seed mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
- B. Topsoil Amendment Plan.
  - 1. Provide copy of topsoil testing report.
  - 2. Recommendations shall be reported in weight per 1000sq. ft. or volume per cu. Yd. for nitrogen, phosphorus, and potash nutrients.
  - 3. List of amendments proposed for topsoil, including application rates.
- C. Product Data: For all pesticides and herbicides used on this project, submit product label and manufacturer's application instructions.

- D. Product Certificates: From Manufacturer, for all fertilizers, limes, and other soil amendments.

## 1.5 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.
- B. Fertilizer: Deliver in waterproof bags showing weight, chemical analysis, and name of manufacturer.
- C. Store seed, fertilizer, lime, and mulch in a dry location.

## 1.7 LIMITS OF SEEDING

- A. Spread topsoil and seed lawn areas. Hydroseed all slopes 3:1 or steeper.

# PART 2 - PRODUCTS

## 2.1 TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, a minimum of 4 percent organic material content; free of stones 1" or larger in any dimension and other extraneous materials harmful to plant growth.
  - 1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
    - a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs or marshes.
- B. Have topsoil tested by a certified soil testing laboratory to determine the type and quantity of soil amendments necessary. Add amendments to topsoil as necessary to meet these requirements.

## 2.2 INORGANIC SOIL AMENDMENTS

- A. If the topsoil analysis indicates the need for inorganic soil amendments, the following standards apply:
- B. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
  - 1. Class: Class O, with a minimum 95 percent passing through No. 8 sieve and a minimum 55 percent passing through No. 60 sieve.
  - 2. Provide lime in form of dolomitic limestone.
- C. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through No. 6 sieve and maximum 10 percent passing through No. 40 sieve.
- D. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- E. Aluminum Sulfate: Commercial grade, unadulterated.
- F. Perlite: Horticultural perlite, soil amendment grade.
- G. Agricultural Gypsum: Finely ground, containing a minimum of 90 percent calcium sulfate.
- H. Sand: Clean, Washed, natural or manufactured, free of toxic materials.
- I. Diatomaceous Earth: Calcined, diatomaceous earth, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
- J. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption capacity by weight.

## 2.3 ORGANIC SOIL AMENDEMENTS

- A. If the topsoil analysis indicates the need for organic soil amendments, the following standards apply:
- B. Compost: Well-composed, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
  - 1. Organic Matter Content: 50 percent of dry weight.
  - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
  - 3. Peat: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water-absorbing capacity of 1100 to 2000 percent.

4. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste, of uniform texture, free of chips, stones, sticks, soil, or toxic materials.
5. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials, free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

## 2.4 HERBICIDES

- A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

## 2.5 FERTILIZER

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast-and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in topsoil analysis reports from a qualified soil-testing agency.
  2. Minimum Composition: No less than 1 lb./1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

## 2.6 SEED

- A. Grass Seed:
  1. All grass seed must be fresh, clean, and dry.
  2. Seed shall have 85% minimum germination, not less than 85% pure seed and not more than 0.5% weed seed.
  3. All seed shall bear an official "N.C. Certified Seed" label. Tags must be attached to each bag delivered on site.

- B. Seed Species

1. General Lawn Areas

Proportion by Weight	Grass Species	Min. % Germination	Min. % Pure Seed	Max. % Weed Seed
10%	2 Types: Kentucky bluegrass ( <u>Poa pratensis</u> ).	80	85	0.50
90%	2 Types: Tall Fescue ( <u>Festuca arundinacea</u> ).	85	98	0.50

2. Low-Maintenance Slope (3:1 or less) – Refer to Erosion Control Requirements for location.

Proportion by Weight	Grass Species	Min. % Germination	Min. % Pure Seed	Max. % Weed Seed
10%	Japanese Clover ( <u>Lespedeza striata</u> ).	85	85	0.50
20%	Chinese Lespedeza ( <u>Lespedeza cuneata</u> ).	85	98	0.50
70%	Tall Fescue ( <u>Festuca arundinacea</u> ).	85	85	0.50

3. Low-Maintenance Slope (Steeper than 3:1) – Refer to Erosion Control Requirements for location.

Proportion by Weight	Grass Species	Min. % Germination	Min. % Pure Seed	Max. % Weed Seed
10%	Japanese Clover ( <u>Lespedeza striata</u> ).	85	85	0.50
20%	Chinese Lespedeza ( <u>Lespedeza cuneata</u> ).	85	98	0.50
70%	Tall Fescue ( <u>Festuca arundinacea</u> ).	85	85	0.50

C. Turf Varieties shall be selected from the 2005 list of recommended Tall Fescue and Kentucky Bluegrass varieties, published by N.C. State University.

## 2.7 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Pine Straw: Fresh, dry and free from debris, pine cones, or soil. Slash Pine is preferred.

C. Peat Mulch: Finely divided or granular texture, with a pH range of 6 to 7.5, containing partially decomposed moss peat, native peat, or reed-sedge peat and having a water absorbing capacity of 1100 to 2000 percent.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8, moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

E. Organic Matter Content: 50 percent of dry weight.

- F. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch, nontoxic, free of plant-growth or germination inhibitors; with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

## 2.7 EROSION-CONTROL MATERIALS

- A. Erosion-Control Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, a minimum of 0.92 lb./sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas to receive lawns and grass for compliance with requirements and for conditions affecting performance of the Work. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Protect adjacent and adjoining areas from hydroseed overspray.

### 3.3 TOPSOIL PLACEMENT FOR LAWNS

- A. Limit subgrade preparation to areas that will be planted in the immediate future.
- B. Loosen subgrade to a minimum depth of 4 inches. Remove stones, sticks and roots larger than 2 inches in any dimension from subgrade, 1" in playing fields. Completely remove trash and other extraneous debris from subgrade.
- C. Have topsoil tested by a certified soil testing laboratory to determine the type and quality of soil amendments necessary.
- D. Sift topsoil to remove stones and other objects larger than 1" in any dimension. Sift topsoil to remove stones and other objects larger than ½" in any dimension in all playing fields. Maximum object size of topsoil shall be achieved by sifting not by hand removal or raking following placement of topsoil.

- E. Mix soil amendments and fertilizers with topsoil at rates required by soil testing. Delay mixing fertilizer if planting does not follow placing of planting soils within 4 days. Either mix soil before spreading or apply soil amendments on surface of spread topsoil and mix thoroughly into top 4 inches (100 mm) of topsoil before planting.
- F. Mix lime with dry soil prior to mixing fertilizer.
- G. Spread topsoil to a minimum depth of six inches (6").

### 3.4 SEEDING LAWNS

- A. Sow seed with a spreader or a seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8km/h). Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.
- B. Do not use wed seed or seed that is moldy or otherwise damaged in transit or storage.
- C. Sow seed at the following rates:
  - 1. Seeding Rates:
    - a. General Lawn Areas – 200 lbs./acre.
    - b. Low-Maintenance Slope (3:1 or less) – 110 lbs./acre
    - c. Low-Maintenance Slope (Steeper than 3:1) – 140 lbs./acre.
- D. Rake seed lightly into top ¼ inch of topsoil, roll lightly, and water with fine spray.
- E. Hydroseed all slopes 3:1 or steeper.
- F. Protect seeded areas 3:1 slope/grade or steeper against erosion by providing erosion-control blankets installed and stapled according to manufacturer's recommendations.
- G. Protect seeded areas less than 3:1 slope/grade against erosion by spreading straw mulch after completion of seeding operations. Spread uniformly at a minimum rate of 2 tons per acre (45 kg per 100 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
  - 1. Anchor straw mulch by crimping into topsoil by suitable mechanical equipment.

### 3.5 MAINTENANCE OF NEW LAWNS

- A. Begin maintenance of lawns immediately after each area is planted and continue until acceptable lawn is established. Maintain seeded lawns until Substantial Completion. Maintain all grassed areas as necessary to ensure a satisfactory lawn is achieved at Substantial Completion.
- B. Footings, foundation walls, and piers: Proportion normal-weight concrete mixture as follows:
  - A. Minimum Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth lawn.

1. Replant bare areas with same materials as for lawns.
  2. Replace disturbed mulch.
- B. Watering: Provide and maintain temporary hoses, and lawn-watering equipment to convey water from a water source to keep lawns uniformly moist to a depth of 4 inches.
1. Provide a source of water for irrigation. Utilize temporary irrigation meters, a well or water trucks as necessary for the water source.
  2. Water seeded areas as necessary to promote vigorous growth of grass but at the minimum rate of 1 inch per week.
  3. Water sodded areas per the requirements of the grower. Maintain moist soil to a depth of at least four inches.
- C. Mow lawns as soon as there is enough top growth to cut with mower set a indicated height. Repeat mowing as required to maintain indicated height without cutting more than 40 percent of the grass height (minimum of 3 mowings). Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass bladed bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowing to maintain following grass height:
- D. Mow grass to a finished height of 2 to 3 inches high.
- E. Apply pre-emergent herbicide to lawns areas. Apply 60-90 days after planting.

### 3.6 SATISFACTORY LAWN

- A. Seeded lawns shall be considered satisfactory/acceptable provided requirements, including maintenance, have been met and a healthy, uniform, close stand of grass is established, free of weeds, bare spots exceeding 5 by 5 inches (125 by 125 mm), and surface irregularities.
- B. Sodded lawns shall be considered satisfactory/acceptable provided requirements, including maintenance, have been met and a healthy, well-rooted, even-colored, viable lawn is established, free of weeds, open joints, bare areas exceeding 5 by 5 inches (125 by 125 mm), and surface irregularities.
- C. Replant lawns that do not meet requirements and continue maintenance until lawns are satisfactory/acceptable.
- D. Substantial Completion of the building and the remainder of the project may be achieved (pending prior Engineer and Owner approval) before achieving a satisfactory/acceptable lawn. Continue to replant and maintain unsatisfactory/unacceptable lawn areas until acceptance is obtained. Warranties for lawns shall begin at the time of acceptance of the lawn.

### 3.7 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by lawn work from sidewalks and paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto surface of roads, walks, or other paved areas.
- B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period until lawn is established. Retain option in paragraph below if steel or synthetic fibers are required.

END OF LAWNS AND GRASSES

## **SECTION 330132 – SEWER AND MANHOLE TESTING**

### **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. Testing Manholes:
    - a. Vacuum Test.
    - b. Exfiltration Test.
  - 2. Testing Gravity Sewer Piping:
    - a. Low-pressure Air Test.
    - b. Infiltration Test.
  - 3. Hydrostatic Testing Pressure Piping.
  - 4. Deflection Testing Plastic Piping.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Testing Manholes:
  - 1. No measurement or direct payment will be made for testing manholes. Cost of testing shall be included in the lump sum price bid.
- B. Testing Gravity Sewer Piping:
  - 1. No measurement or direct payment will be made for testing of gravity sewer piping. Cost of testing shall be included in the lump sum price bid.
- C. Hydrostatic Testing Pressure Piping:
  - 1. No measurement or direct payment will be made for testing of pressure sewer piping. Cost of testing shall be included in the lump sum price bid.
- D. Deflection Testing Plastic Piping
  - 1. No measurement or direct payment will be made for testing of sewer piping. Cost of testing shall be included in the lump sum price bid.

#### **1.4 REFERENCES**

- A. ASTM International:

1. ASTM C1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test.
2. ASTM D2122 - Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

## 1.5 SUBMITTALS

- A. Submit the following prior to start of testing:
  1. Testing procedures.
  2. List of test equipment.
  3. Testing sequence schedule.
  4. Provisions for disposal of flushing and test water.
  5. Certification of test gauge calibration.
6. Deflection mandrel drawings and calculations.
7. Test Reports: Indicate results of manhole and piping tests.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

## PART 2 - PRODUCTS

### 2.1 VACUUM TESTING EQUIPMENT

- A. Vacuum pump.
- B. Vacuum line.
- C. Vacuum tester base with compression band seal and outlet port.
- D. Shut-off valve.
- E. Stop watch.
- F. Plugs.
- G. Vacuum gauge, calibrated to 0.1 inch Hg

### 2.2 EXFILTRATION TEST EQUIPMENT

- A. Plugs.

- B. Pimp.
- C. Measuring device

## 2.3 AIR TEST EQUIPMENT

- A. Air compressor.
- B. Air supply line.
- C. Shut-off valves.
- D. Pressure regulator.
- E. Pressure relief valve.
- F. Stop watch.
- G. Plugs.
- H. Pressure gauge, calibrated to 0.1 psi.

## 2.4 INFILTRATION TEST EQUIPMENT

- A. Weirs.

## 2.5 HYDROSTATIC TEST EQUIPMENT

- A. Hydro pump.
- B. Pressure hose.
- C. Water meter.
- D. Test connections.
- E. Pressure relief valve.
- F. Pressure gauge, calibrated to 0.1 psi.

## 2.6 DEFLECTION TEST EQUIPMENT

- A. Go, No-Go mandrels.
- B. Pull/retrieval ropes.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify manholes and piping are ready for testing.
- B. Verify trenches are backfilled.
- C. Verify pressure piping concrete reaction support blocking or mechanical restraint system is installed.

### 3.2 PIPING PREPARATION

- A. Lamping:
  - 1. Lamp gravity piping after flushing and cleaning.
  - 2. Perform lamping operation by shining light at one end of each pipe section between manholes; observe light at other end; reject pipe not installed with uniform line and grade; remove and reinstall rejected pipe sections; re-clean and lamp until pipe section achieves uniform line and grade.
- B. Plug outlets, wye-branches and laterals; brace plugs to resist test pressures.

### 3.3 FIELD QUALITY CONTROL

- A. Testing Gravity Sewer Piping:
  - 1. Low-pressure Air Test:
    - a. Test each section of gravity sewer piping between manholes.
    - b. Introduce air pressure slowly to approximately 4 psig.
      - 1) Determine ground water elevation above spring line of pipe for every foot of ground water above spring line of pipe, increase starting air test pressure by 0.43 psig; do not increase pressure above 10 psig.
    - c. Allow pressure to stabilize for at least five minutes. Adjust pressure to 3.5 psig or increased test pressure as determined above when ground water is present. Start test.
    - d. Test:
      - 1) Determine test duration for sewer section with single pipe size from the following table. Do not make allowance for laterals.

Nominal Pipe Size (in.)	Minimum Test Time, min/ 100 feet
3	0.2
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1

18	2.4
21	3.0
24	3.6
27	4.2
30	4.8
33	5.4
36	6.0

- 2) Record drop in pressure during test period; when air pressure has dropped more than 1.0 psig during test period, piping has failed; when 1.0 psig air pressure drop has not occurred during test period, discontinue test and piping is accepted.
- 3) When piping fails, determine source of air leakage, make corrections and retest; test section in incremental stages until leaks are isolated; after leaks are repaired, retest entire section between manholes.
2. Test pipe larger than 36 inches diameter with exfiltration test not exceeding 100 gallons for each inch of pipe diameter for each mile per day for each section under test. Perform test with minimum positive head of 2 feet.
3. Infiltration Test:
  - a. Use only when gravity piping is submerged in ground water minimum of 4 feet above crown of pipe for entire length being tested.
  - b. Maximum Allowable Infiltration: 100 gallons per inch of pipe diameter for each mile per day for section under test, include allowances for leakage from manholes. Perform test with minimum positive head of 2 feet.

B. Testing Pressure Sewer Piping:

1. Hydrostatic Leakage Test:
  - a. Hydrostatically test each portion of pressure piping, including valved sections, at 1.5 times working pressure of piping based on elevation of lowest point in piping corrected to elevation of test gauge, but in no case less than 150 psi.
  - b. Fill section to be tested with water slowly, expel air from piping at high points. Install corporation cocks at high points. Close air vents and corporation cocks after air is expelled, and raise pressure to specified test pressure.
  - c. Observe joints, fittings and valves under test. Remove and renew cracked pipe, joints, fittings, and valves showing visible leakage regardless of the amount of leakage.
  - d. Correct visible deficiencies and continue testing at same test pressure for additional 2 hours to determine leakage rate. Maintain pressure within plus or minus 5.0 psig of test pressure. Leakage is defined as quantity of water supplied to piping necessary to maintain test pressure during period of test.
  - e. Compute maximum allowable leakage by the following formula:

$L = (SD\sqrt{P})/C$
L = allowable, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
p = average test pressure during leakage test, in psig

C = 133,200

When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.

- f. When test of pipe indicates leakage greater than allowed, locate source of leakage, make corrections and retest until leakage is within allowable limits. Correct visible leaks regardless of quantity of leakage.

C. Deflection Testing of Plastic Sewer Pipe:

1. Perform vertical ring deflection testing on PVC and ABS sewer piping, after backfilling has been in place for at least 30 days but not longer than 12 months.
2. Allowable maximum deflection for installed plastic sewer pipe limited to 5 percent of original vertical internal diameter.
3. Perform deflection testing using properly sized rigid ball or 'Go, No-Go' mandrel.
4. Furnish rigid ball or mandrel with diameter not less than 95 percent of base or average inside diameter of pipe as determined by ASTM standard to which pipe is manufactured. Measure pipe in compliance with ASTM D2122.
5. Perform test without mechanical pulling devices.
6. Locate, excavate, replace and retest pipe exceeding allowable deflection.

D. Testing Manholes:

1. General: Test using air whenever possible prior to backfilling to assist in locating leaks. Make joint repairs on both outside and inside of joint to ensure permanent seal. Test manholes with manhole frame set in place. Contractor may select to perform vacuum or exfiltration testing.
2. Vacuum test in accordance with ASTM C1244 and as follows:
  - a. Plug pipe openings; securely brace plugs and pipe.
  - b. Inflate compression band to effect seal between vacuum base and structure; connect vacuum pump to outlet port with valve open; draw vacuum to 10 inches of Hg; close valve; start test:
  - c. Test:

- 1) Determine test duration for manhole from the following table:

Manhole Diameter	Test Period
4 feet	60 seconds
5 feet	75 seconds
6 feet	90 seconds

- 2) Record vacuum drop during test period; when vacuum drop is greater than 1 inch of Hg during test period, repair and retest manhole; when vacuum drop of 1 inch of Hg does not occur during test period, discontinue test and accept manhole.
- 3) When vacuum test fails to meet 1 inch Hg drop in specified time after repair, repair and retest manhole.
3. Exfiltration Test:
  - a. Plug pipes in manhole; remove water in manhole; observe plugs over period of not less than 2 hours to ensure there is no leakage into manhole.
  - b. Determine ground water level outside manhole.
  - c. Fill manhole with water to within 4 inches of top of cover frame. Prior to test, allow manhole to soak from minimum of 4 hours to maximum of 72 hours; after

soak period, adjust water level inside manhole to within 4 inches of top of cover frame.

- d. Measure water level from top of manhole frame; at end of 4 hour test period, again measure water level from top of manhole frame; compute drop in water level during test period.
- e. Manhole exfiltration test is considered satisfactory when drop in water level is less than values listed in table below:

Manhole Depth (feet)	Allowable Leakage inches for Manhole Diameter		
	4 feet	5 feet	6 feet
4	0.11	0.14	0.17
6	0.17	0.21	0.26
8	0.23	0.29	0.35
10	0.28	0.35	0.42
12	0.34	0.43	0.51
14	0.40	0.50	0.60
16	0.45	0.56	0.68
18	0.51	0.64	0.77
20	0.57	0.71	0.86
22	0.62	0.78	0.93
24	0.68	0.85	1.02
26	0.74	0.93	1.11
28	0.79	0.99	1.19
30	0.85	1.06	1.28

4. When unsatisfactory test results are achieved, repair manhole and retest until result meets criteria; repair visible leaks regardless of quantity of leakage.

END OF SEWER AND MANHOLE TESTING

## **SECTION 330524 - HORIZONTAL DIRECTIONAL DRILLING**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Excavation for approach trenches and pits.
  - 2. Horizontal directional drilling.
  - 3. Pipe.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Horizontal Directional Drilling:
  - 1. Basis of Measurement: By linear foot.
  - 2. Basis of Payment: Includes:
    - a. Excavation
    - b. Fusing
    - c. Drilling
    - d. Pipe
    - e. Accessories
    - f. HDPE Mechanical Joint Adapter
    - g. Backfilling
    - h. Testing.

#### **1.4 REFERENCES**

- A. American Association of State Highway and Transportation Officials:
  - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup>).
2. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
4. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
5. ASTM F1962 - Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings.

C. National Utility Contractors Association:

1. NUCA - HDD Installation Guidelines.

D. The Plastic Pipe Institute, Inc.:

1. PPI Generic Butt Fusion Joining Procedure TR-33.

## 1.5 DESIGN REQUIREMENTS

A. Design Criteria:

1. Drilling Steering System: Remote with continuous electronic monitoring of boring depth and location.
2. Directional Change Capability: 90 degree with 35 foot radius curve.
3. Minimum distance for single bores and between boring pits:

Pipe Size	Boring Distance
1 to 1-1/2 inches	400 feet
2 to 2-1/2 inches	350 feet
3 to 6 inches	300 feet

4. Ratio of Reaming Diameter to Pipe Outside Diameter:

- a. Nominal pipe diameter of 6 inches and smaller: 1.5 maximum.
- b. Nominal pipe diameter larger than 6 inches: Submit recommended ratio and reaming procedures for review.

## 1.6 SUBMITTALS

A. Shop Drawings:

1. Submit technical data for equipment, method of installation, and proposed sequence of construction.
  2. Include information pertaining to pits, dewatering, method of spoils removal, equipment size and capacity, equipment capabilities including installing pipe on radius, type of drill bit, drilling fluid, method of monitoring line and grade and detection of surface movement, name plate data for drilling equipment and mobile spoils removal unit.
- B. Product Data:
1. Identify source of water used for drilling.
  2. Submit copy of approvals and permits for use of water source.
- C. Project Record Documents: Record actual locations of pipe and invert elevations.
- D. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.
- E. Record actual depth of pipe at 25-foot intervals.
- F. Record actual horizontal location of installed pipe.
- G. Show depth and location of abandoned bores.
- H. Record depth and location of drill bits and drill stems not removed from bore.

## 1.7 QUALITY ASSURANCE

- A. Perform work in accordance with the following:
1. NUCA HDD Installation Guidelines.
  2. ASTM F1962.

## 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary end caps and closures on piping and fittings until pipe is installed.
- B. Protect pipe from entry of foreign materials and water by temporary covers, completing sections of work, and isolating parts of completed system.
- C. Accept products on site in manufacturer's original containers or configuration. Inspect for damage.
- D. Use shipping braces between layers of stacked pipe. Stack piping lengths no more than 3 layers high.

- E. Support pipes with nylon slings during handling.

## PART 2 PRODUCTS

### 2.1 DRILLING FLUID

- A. Drilling Fluid: Liquid bentonite clay slurry; totally inert with no environmental risk.

### 2.2 PIPE

- A. Water Distribution System Pipe: HDPE DR-9.
- B. Sanitary Sewage System Pipe: HDPE SDR-9.

### 2.3 FILL MATERIALS

- A. On-site suitable material.

### 2.4 WATER SOURCE

- A. Water: Potable.

### 2.5 ACCESSORIES

- A. HDPE mechanical joint adapter meeting the requirements of AWWA C111/ANSI A21.11.
- B. Mechanical joint accessory kits
- C. Grout: 1 part Portland cement, 3 parts mortar sand, and water.

## PART 3 EXECUTION

### 3.1 PREPARATION

- A. Notification: The Town Public Utilities Department should be notified at least forty-eight (48) hours prior to beginning the work of this Section.
- B. Call NC One Call service at 811 not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.
- C. Locate, identify, and protect from damage any utilities indicated to remain.
- D. Identify required lines, levels, contours, and datum locations.
- E. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- F. Protect benchmarks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

### 3.2 DEWATERING

- A. Intercept and divert surface drainage, precipitation, and groundwater away from excavation through use of dikes, curb walls, ditches, pipes, sumps or other means.
- B. Develop and maintain substantially dry subgrade during drilling and pipe installation.

### 3.3 EXCAVATION

- A. Excavate subsoil as specified in Section 31 23 17 Trenching and Backfilling.
- B. Excavate approach trenches and pits as site conditions require. Minimize number of access pits.
- C. Provide sump areas to contain drilling fluids.
- D. Restore areas after completion of drilling and carrier pipe installation.

### 3.4 DRILLING

- A. Drill pilot bore with vertical and horizontal alignment as indicated on drawings and details.
- B. Guide drill remotely from ground surface to maintain alignment by monitoring signals transmitted from drill bit.
  1. Monitor depth, pitch, and position.
  2. Adjust drill head orientation to maintain correct alignment.
- C. Inject drilling fluid into bore to stabilize hole, remove cuttings, and lubricate drill bit and pipe.

- D. Continuously monitor drilling fluid pumping rate, pressure, viscosity, and density while drilling pilot bore, back reaming, and installing pipe to ensure adequate removal of soil cuttings and stabilization of bore.
  - 1. Provide relief holes when required to relieve excess pressure.
  - 2. Minimize heaving during pullback.
- E. Calibrate and verify electronic monitor accuracy during first 50 feet of bore in presence of Town Public Utilities Department before proceeding with other drilling. Excavate minimum of four test pits spaced along first 50 feet bore to verify required accuracy. When required accuracy is not met, adjust equipment or provide new equipment capable of meeting required accuracy.
- F. After completing pilot bore, remove drill bit.

### 3.5 DRILLING OBSTRUCTIONS

- A. When obstructions are encountered during drilling, notify Town Public Utilities Department immediately. Do not proceed around obstruction without Town Public Utilities Department's approval.
- B. For conditions requiring more than 3 feet deviation in horizontal alignment, submit new shop drawings to Town Public Utilities Department for approval before resuming work.
- C. Maintain adjusted bore alignment within easement or right-of-way.

### 3.6 PIPE INSTALLATION

- A. After completing pilot bore, remove drill bit. Install reamer and pipe pulling head. Select reamer with minimum bore diameter required for pipe installation.
- B. Attach pipe to pipe pulling head. Pull reamer and pipe to entry pit along pilot bore.
- C. Inject drilling fluid through reamer to stabilize bore and lubricate pipe.
- D. Install piping with horizontal and vertical alignment as shown on drawings and details.
- E. Protect and support pipe being pulled into bore so pipe moves freely and is not damaged during installation.
- F. Do not exceed pipe manufacturer's recommended pullback forces.

- G. Install trace wire continuous with each bore. Splice trace wire only at intermediate bore pits. Tape or insulate trace wire to prevent corrosion and maintain integrity of pipe detection.
  - 1. Terminate trace wire for each pipe run at structures along pipe system.
  - 2. Provide extra length of trace wire at each structure, so trace wire can be pulled 3 feet out top of structure for connection to detection equipment.
  - 3. Test trace wire for continuity for each bore before acceptance.
- H. Provide sufficient length of pipe to extend past termination point to allow connection to other pipe sections.
- I. Slip the gland ring over the pipe end and then butt fuse the HDPE MJ adapter to the end of the pipe using the PPI generic Butt Fusion Joining Procedure TR-33.
- J. Mark location and depth of bore with spray paint on paved surfaces, and wooden stakes on non-paved surfaces at 25-foot intervals.

### 3.7 SLURRY REMOVAL AND DISPOSAL

- A. Contain excess drilling fluids at entry and exit points until recycled or removed from site. Provide recovery system to remove drilling spoils from access pits.
- B. Remove, transport and legally dispose of drilling spoils.
  - 1. Do not discharge drilling spoils in sanitary sewers, storm sewers, or other drainage systems.
  - 2. When drilling in suspected contaminated soil, test drilling fluid for contamination before disposal.
- C. When drilling fluid leaks to surface, immediately contain leak and barricade area from vehicular and pedestrian travel before resuming drilling operations.
- D. Complete cleanup of drilling fluid at end of each work day.

### 3.8 ERECTION TOLERANCES

- A. Maximum Variation From Horizontal Position: 12 inches.
- B. Maximum Variation From Vertical Elevation: 2 inches.
- C. Minimum Horizontal and Vertical Clearance From Other Utilities: 12 inches.
- D. When pipe installation deviates beyond specified tolerances, abandon bore, remove installed pipe, re-bore, and reinstall pipe in correct alignment.

- E. Fill abandoned bores greater than 3" in diameter with grout or flowable fill material.

### 3.9 FIELD QUALITY CONTROL

- A. Upon completion of pipe installation, test pipe in accordance with the following:
  - 1. Water Distribution Pipe Testing: Section 33 11 00 Water Distribution.

### 3.10 CLEANING

- A. Upon completion of drilling and pipe installation, remove drilling spoils, debris, and unacceptable material from approach trenches and pits. Clean up excess slurry from ground.
- B. Restore approach trenches and pits to original condition.

END OF HORIZONTAL DIRECTIONAL DRILLING

## **SECTION 331100 - WATER UTILITY DISTRIBUTION**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Pipe and fittings for public line, including potable water line and fire water line.
  - 2. Tapping sleeves and valves.
  - 3. Valves and fire hydrants.
  - 4. Underground pipe markers.

#### **1.3 DEFINITIONS**

- A. Off-Site Select Borrow: Approved soil material obtained off-site when specified or when sufficient approved soil material is not available from excavations.
- B. Unsuitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that does not meet the definition and requirements of suitable soil.
- C. Suitable Soil: Soil produced from excavation of drainage features, cut to sub-grade, or required stripping that meets the definition and requirements of suitable soil.
- D. Topsoil: Soil produced from stripping the top or upper 4-8" soil layer from areas to be further excavated, re-landscaped, or re-graded without contamination from the subsoil. Stripping of topsoil is not required where excavation width is less than 10' or for the installation of pipe utilities. Topsoil shall be stockpiled on site at designation location for further use. Topsoil shall not be removed from site.
- E. Base Course: The layer placed between the sub-grade and surface pavement in a paving system.
- F. Excavation: Removal of material encountered above sub-grade elevations and to the lines and dimensions indicated.

- G. Porous Fill: Fill material supporting the slab on grade that also minimizes upward capillary flow of water.
- H. Structures: Buildings, slabs, curbs, utility appurtenances, tanks, retaining walls or other man-made stationary features constructed above or below ground surface.
- I. Sub-grade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below topsoil materials.
- J. Unauthorized excavation: Removal of materials beyond indicated sub-grade elevations or dimensions without direction by the Town Public Utilities Department. Unauthorized excavation, as well as remedial work directed by the Town Public Utilities Department, shall be at the Contractor's expense.
- K. Undercut excavation: Excavation below sub-grade elevations or beyond indicated lines and dimensions as directed by Town Public Utilities Department. Authorized undercut excavation and replacement material will be paid for according to Contract unit price for UNDERCUT and BACKFILL.
- L. Utilities: On-site underground pipes, conduits, ducts and cables.

#### 1.4 MEASUREMENT AND PAYMENT

##### A. Pipe and Fittings:

- 1. Basis of Measurement: Per Lump Sum.
- 2. Basis of Payment includes:
  - a. Excavation for piping and all fittings, including all valves, sleeves, hydrants and blow-offs.
  - b. Removal of unsuitable soil material.
  - c. Piping and fittings, with the exception of valves, tapping sleeves and tapping valves, and fire hydrants.
  - d. Concrete thrust restraints.
  - e. Connection to public utility water source.
  - f. Backfilling with suitable trench excavation or on-site suitable soil.
  - g. Testing.

##### B. Valves:

- 1. Basis of Measurement: Lump Sum
- 2. Basis of Payment includes:
  - a. Valve
  - b. Accessories and kits
  - c. Valve Box
  - d. Concrete Collar as required

- e. Blocking
- f. Backfilling

C. Tapping Sleeve and Tapping Valve

- 1. Basis of Measurement: Lump Sum.
- 2. Basis of Payment includes:
  - a. Tapping sleeve and tap valve
  - b. Testing of assembly before wet tap
  - c. Cutting the wet tap
  - d. Blocking
  - e. Backfilling

D. Fire Hydrant

- 1. Basis of Measurement: Lump Sum.
- 2. Basis of Payment includes:
  - a. Fire hydrant
  - b. Blocking and rodding
  - c. Drainage aggregate
  - d. Backfilling
  - e. Painting

E. Blow Off

- 1. Basis of Measurement: Lump Sum
- 2. Basis of Payment includes:
  - a. Complete blow off assembly per drawings and details
  - b. Blocking
  - c. Backfilling

F. Backflow Preventer

- 1. Basis of Measurement: Per Lump Sum
- 2. Basis of Payment includes:
  - a. Complete backflow preventer assembly
  - b. Accessories
  - c. Enclosure
  - d. Blocking backfilling
  - e. Testing

## 1.5 REFERENCES

- A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. American Society of Mechanical Engineers:
1. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
- C. ASTM International:
1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
  2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  3. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
  4. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).
  5. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  6. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
  7. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
  8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
  9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
  10. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
  11. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- D. American Water Works Association:
1. AWWA C104 - ANSI Standard for Cement Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
  2. AWWA C110 - ANSI Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm), for Water.
  3. AWWA C111 - ANSI Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  4. AWWA C115 - ANSI Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
  5. AWWA C151 - ANSI Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
  6. AWWA C153 - ANSI Standard for Ductile-Iron Compact Fittings for Water Service.
  7. AWWA C200 - Steel Water Pipe 6 In. (150 mm) and Larger.
  8. AWWA C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied.

9. AWWA C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. and Larger - Shop Applied.
10. AWWA C206 - Field Welding of Steel Water Pipe.
11. AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
12. AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
13. AWWA C213 - Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
14. AWWA C300 - Reinforced Concrete Pressure Pipe, Steel-Cylinder Type.
15. AWWA C301 - Prestressed Concrete Pressure Pipe, Steel-Cylinder Type.
16. AWWA C500 - Gate Valves for Water and Sewage Systems.
17. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
18. AWWA C605 - Water Treatment - Underground Installation of Polyvinyl Chloride PVC Pressure Pipe and Fittings for Water.
19. AWWA C606 - Grooved and Shouldered Joints.
20. AWWA C700 - Cold-Water Meters - Displacement Type, Bronze Main Case.
21. AWWA C701 - Cold-Water Meters - Turbine Type, for Customer Service.
22. AWWA C702 - Cold-Water Meters - Compound Type.
23. AWWA C706 - Direct-Reading, Remote-Registration Systems for Cold-Water Meters.
24. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. through 12 In. (100 mm Through 300 mm), for Water Distribution.
25. AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 36 In. (350 mm Through 1,200 mm), for Water Transmission and Distribution.
26. AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

E. Manufacturer's Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joint between Tapping Sleeves and Tapping Valves.

F. National Fire Protection Agency:

1. NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

## 1.6 SUBMITTALS

- A. Product Data: Submit data on all pipe materials, pipe fittings, valves and accessories.
- B. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.
- C. Manufacturer's Certificate: Certify that products meet or exceed specifications.
- D. Record Documents (As-Built Drawings): Record location and depth of cover for pipe runs, valves, tees, and other fittings. Identify and describe variations to drawings and

discovery of unidentified buried objects. Provide color photographs for all tee and valve connections and fire hydrant assemblies taken prior to placing any backfill. Photographs shall be numbered and keyed to the appropriate location on the as-built drawings.

## 1.7 QUALITY ASSURANCE

- A. All work shall conform to applicable AWWA and ASTM standards as the manufacturer's recommendations and instructions.

## 1.8 INSTALLER QUALIFICATIONS

- A. Installer shall be a licensed underground utility contractor licensed for such work in the State of North Carolina. Installing contractor's license status shall be current.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. All pipe, of whatever material, shall be transported, handled, stored, and installed in strict compliance with applicable AWWA and ASTM standards as well as the manufacturer's instructions and recommendations.
- B. Deliver and store valves in shipping containers with labeling in place.
- C. Block individual and stockpiled pipe lengths to prevent moving.
- D. Do not place pipe or pipe materials on private property or in areas obstructing pedestrian or vehicle traffic.
- E. Store polyethylene materials out of sunlight.

## 1.10 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

## PART 2 PRODUCTS

### 2.1 WATER PIPING

- A. Ductile Iron Pipe: AWWA C151. Bituminous outside coating: AWWA C151. Pipe Mortar Lining: AWWA C104, double thickness. Polyethylene Encasement: AWWA C105.
  - 1. Ductile cast iron pipe shall be Grade 60-42-10 centrifugally cast in accordance with ANSI Standard A21.51 (AWWA C151), latest revision for 200 psi operating

pressures plus surge allowance of 100 psi. Wall thickness and strength shall conform to ANSI Standard A21.50 for cover as shown on the drawings and details. Each pipe shall be hydrostatically tested, before shipment, to a minimum of 500 psi. Factory tests and basis for acceptance shall be as specified in ANSI Standard A21.51. Unless otherwise specified, thickness class shall conform to ANSI A21.51 (AWWA C151).

- a. Bells for push-on joints shall conform to the requirements of ANSI Standard A21.51, such as "Fastite," "Tyton", "Bell-Tite", or equal. Pipe shall be nominal 18' lengths. Joint detail, including rubber gaskets, shall conform to ANSI Standard Specification A21.11., AWWA C111, latest revision.
  - b. The pipe shall have an outside pipe coating of bituminous material in accordance with AWWA C151, latest revision. The final coat shall be continuous and smooth, being neither brittle when subjected to low temperatures nor sticky when exposed to hot sun. The coating shall be strongly adherent to the pipe at all temperatures.
  - c. Pipe 4"-12" shall have a minimum wall thickness equal to or greater than that of pressure class 350, 12"-20" shall have a minimum wall thickness equal to or greater than that of pressure class 300, and 24" pipe shall have a minimum wall thickness equal to or greater than that of pressure class 250. Pipe 6" and larger shall be Class 50. 4" diameter pipe shall be Class 51 or 52.
2. Fittings for ductile iron pipe sizes 4"-12" shall be cast from ductile iron in accordance with ANSI/AWWA C153/A21.53.
- a. All fittings shall be Class 350 ductile iron fittings, mechanical joint. Mechanical joints shall conform to ANSI/AWWA A21.11/C111. Wall and socket thicknesses shall be equal to Class 54 ductile iron pipe as specified in ANSI/AWWA A21.51/C151. Ductile iron shall be in accordance with ASTM A563 with minimum physical qualities of 70,000 psi tensile strength, 50,000 psi yield strength, and 5% elongation.
  - b. All ductile cast iron fittings shall have cement mortar lining conforming to ANSI Standard A21.4, latest edition. Buried fittings shall be given a full coat inside and outside of a bituminous coating which conforms to ANSI 21.4, latest revision.
3. Mechanical jointing ductile iron pipe shall be used only at the specific locations indicated on the drawings and details or as approved by the Town Public Utilities Department. The mechanical joint shall consist of:
- a. a bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting;
  - b. a pipe or fitting spigot;
  - c. a sealing gasket;
  - d. a separate cast iron follower gland having cored or drilled bolt holes; and (5) tee head bolts and hexagon nuts. The joint shall be designed to

permit normal expansion, contraction and deflection of the pipe or fitting while maintaining a leak proof joint connection. The mechanical joint shall conform to the requirements of ANSI Standard Specification A21.11 and AWWA C111 Specifications, latest revision.

4. Ductile iron flanged pipe shall be supplied in accordance with ANSI/AWWA C115/A21.15. Pipe barrels and flanges shall have a taper pipe thread (NPT) in accordance with B1.20.1, with thread diameters adapted to ductile iron pipe standard outside diameters. Ductile iron pipe used for flanging shall be centrifugally cast in metal molds and shall meet the requirements of ANSI/AWWA C151/A21.51. Flanges shall conform to ANSI/AWWA C110/A21.10. Flanged pipe shall be furnished in maximum length of 17'6" for sizes 4-48". The flanges shall conform to the drilling and facing requirements of ANSI B16.1 Class 125 flanges. Face to face dimensions shall conform to a tolerance of  $\pm 0.12$ " for sizes 3-64". The minimum class thickness for ductile iron flanged pipe to be threaded is class 53.
- B. Polyvinyl Chloride (PVC): AWWA C900 DR 18 Class 150 (pipe 4" – 12") and AWWA C905, DR 18 Class 150 (pipe larger than 12").
1. Fittings for PVC pipe sizes " and larger shall be cast from ductile iron in accordance with ANSI/AWWA C153/A21.53.
  2. Ductile iron fittings shall have a working pressure rating of 350 psi for fitting sizes 12" and less. Fitting over 12" shall have a minimum rated working pressure of 250 psi. Mechanical joints shall conform to ANSI/AWWA A21.11/C111. Wall and socket thicknesses shall be equal to Class 54 ductile iron pipe as specified in ANSI/AWWA A21.51/C151. Ductile iron shall be in accordance with ASTM A563 with minimum physical qualities of 70,000 psi tensile strength, 50,000 psi yield strength, and 5% elongation.
    - a. All ductile cast iron fittings shall have cement mortar lining conforming to ANSI Standard A21.4, latest edition. Buried fittings shall be given a full coat inside and outside of a bituminous coating which conforms to ANSI 21.4, latest revision.
    - b. Appropriate transition gaskets shall be utilized for the SDR or class of PVC pipe.
  3. The pipe shall be furnished in nominal lengths of 20'.
- C. Polyvinyl Chloride (PVC): PVC pipe of 3" nominal diameter and less shall conform to ASTM Specification D-2241, "Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe (SDR-PR)", as it applies to Class 12454 (A or B) polyvinyl chloride plastic pipe, SDR 21 water pressure ratings of 200 psi at 23 C (73.4 F), with minimum physical requirements as listed in the following table.

NOMINAL SIZE INCHES	OUTSIDE DIAMETER INCHES	MIN. WALL THICKNESS INCHES	WEIGHT/ MO FT. POUNDS	WORKING PRESSURE PSI
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¾	1.0501	0.060	11.8	200
1	1.315	0.063	15.9	200
1-1/4	1.660	0.079	24.8	200
1-1/2	1.900	0.090	32.2	200
2	2.375	0.113	50.8	200
2-1/2	2.875	0.137	74.2	200
3	3.500	0.167	110.0	200

1. Fittings for PVC ¾" – 2" shall be brass compression X MIP fittings. Solvent weld (glue) fittings will not be accepted.

- D. Pipe with nominal diameters of 4" and larger shall ASTM Specification D-2241, "Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe (SDR-PR)," as it applies to Class 12454 (A or B) polyvinyl chloride plastic pipe, SDR 21 water pressure ratings of 200 psi at 23°C (73.4°F).

## 2.2 TAPPING SLEEVES AND VALVES

- A. Tapping Sleeves: Furnish and install tapping sleeve and valve at the location(s) shown on the Contract Drawings and as required herein. The tapping sleeve and valve shall be suitable for wet installation without interrupting water service in any manner. The tapping sleeve and valve shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings.
  1. The tapping sleeve shall be fully gasketed wrap around tapping sleeve. The sleeve body shall be 18-8 stainless steel. The bolts and nuts shall be 18-8 stainless steel. The gasket shall be gridded virgin GPR compounded for water service. ASTM D2000-80M 4AA607. The outlet gasket is a Buna-N. The flange shall be ductile iron. The tapping sleeve shall be fitted with a female ¾" NPT and supplied with a ¾" plug with square head.
- B. Tapping Valves:
  1. Tapping valves shall be "O" ring type with mechanical joint and conforming to AWWA C500-80 non-rising stem construction. Inlet flange end shall be Class 125 (ASME B16.1). The valves shall be as specified under section 2.3 of this specification for gate valves.

## 2.3 VALVES AND FIRE HYDRANTS

- A. Gate Valves: All gate valves shall be resilient seated wedge type that fully comply with the requirements of the latest revision of AWWA Standard C-509. All gate valves shall open by turning in a counterclockwise direction. All operating nuts, hand wheels and chain wheels shall have the direction of opening cast on them.
  1. Valves 2" and larger shall be iron body, bronze mounted, resilient seat type.

2. All valves other than flanged end valves shall be of the non-rising stem type.
3. All flanged gate valves for hand operation shall be of the OS&Y type with conventional packing for either wheel or chain operation, as shown on the drawings and details.
4. Unless otherwise shown on the drawings or stated in the proposal, all gate valves 2"-12" shall be designed for a working pressure of 200 psi and shall be tested to a minimum pressure of 400 psi.
5. All gate valves 14"-24" shall be designed for a working pressure of 150 psi and hydrostatically tested to a minimum pressure of 300 psi.
6. All buried valves shall be provided with a 2-piece screw-type valve box.
7. Gate valves shall be of the mechanical joint type unless otherwise indicated on the drawings and details.
8. All gate valves shall be manufactured by the American-Darling Co., Mueller Co., M&H Valve, Dresser, Clow, Kennedy Valve Co., or equal.

B. Butterfly Valves: Butterfly valves shall conform to AWWA C-504, latest revision.

1. All valves for buried service shall have cast iron bodies with integrally cast mechanical joint ends conforming to AWWA C-111, latest revision.
2. Valves for above ground use shall be short bodied with flanges conforming to ANSI B16.1, latest revision.
3. The valve discs shall be designed to rotate 90 degrees from full open to tight shut position and shall have adjustable mechanical stops to govern the rotation of the disc.
4. The valve shall have a Buna-N or a Buna-S valve seats with bronze or stainless steel seating rings.
5. The stuffing boxes shall be integrally cast with the valve body.
6. The shaft bearings shall be of the self-lubricating sleeve type with thrust bearings to keep the valve disc centered.
7. Valves shall be pressure class 200 unless otherwise specified on the drawings.

C. Swing Check Valves:

1. Valves 2" to 12": Swing check valves shall conform to AWWA C 508, latest revision.
2. Small swing check valves shall have iron bodies with NPT ends.
3. The swing disc shall be internally weighted or spring loaded and constructed of composition or bronze with rubber seats.
4. Valves shall be rated at 175 lb. service water pressure or 200 lb. WOG.
5. Valves for use in aboveground installations shall be flanged without side spring and lever or when position.

D. Fire Hydrants: Fire hydrants shall be of the compression or gate type conforming to AWWA C-502, latest revision and shall be the Owner's standard which consists of M & H 129 Traffic Model.

1. All hydrants shall have a bronze to bronze main valve assembly.

2. The hydrant shall have two 2-1/2" hose nozzles with caps and one 4-1/2" steamer connection conforming to the Currituck County Water System Standards.
3. Threads on nozzles and caps and operating nuts shall conform to those adopted by the Owner as standard.
4. Hydrants shall open by turning counterclockwise and shall be so marked.
5. The hydrant main valve shall meet or exceed the flow requirements of AWWA C-502 and shall be at least 5-1/4" in diameter and the hydrant elbow shall be a 6" MJ end.
6. Elbow shall have interior coated with minimum 4 mils thickness epoxy in accordance with AWWA C550.
7. The hydrant barrel shall be of such length to provide a minimum of 3'6" of bury.
8. All hydrants shall be traffic models with breakable safety sleeve stem coupling with SS stem coupling pins.
9. The Contractor shall include in the base bid price for fire hydrants and accessories all hydrant barrel extensions necessary to set the pumper nozzle at the specified height at the location shown on the drawings and details.
10. Hydrants shall be designed for a 300 psi test pressure and a 150 psi working pressure.
11. All hydrants shall be factory primed and finish painted.
12. Final color of the hydrant body shall be Rustoleum enamel or equal "Safety Red".
13. All hydrants shall be repainted by the contractor.
14. Painting requirements for hydrant bonnet:  
6" Waterline- Rustoleum enamel or equal "Safety Yellow"  
8" Waterline- Rustoleum enamel or equal "Safety Orange"  
10" and larger Waterline- Rustoleum enamel or equal "Safety Green"

## 2.4 BACKFLOW PREVENTERS

- A. All existing and proposed water services, dedicated fire and irrigation lines and private distribution systems must be provided with an approved backflow prevention assembly in accordance with the requirements of the Town of Windsor and the Rules Governing Public Water Systems as found in Title 15A, Subchapter 18C of the North Carolina Administrative Code.
- B. Approved backflow prevention assemblies shall be installed above ground. Assemblies may be installed inside of buildings as long as there are no unprotected taps between the main and the building.
- C. The backflow prevention assembly(s) must be readily accessible at all times. Readily accessible means that only a one-piece cover must be removed for an outside installation to test or perform maintenance on the assembly.
- D. Backflow prevention assemblies must be installed, tested and maintained by persons that have an approved cross connection School. It is also required that all

assemblies be tested at the time of installation and annually thereafter. All assemblies must also have the rubber parts changed every five years.

## 2.5 FIRE HYDRANT LOCATION MARKERS

- A. Contractor shall install at all hydrant locations a reflective hydrant marker, Stimpsonite, Model 88AB, two-way blue reflector in centerline of pavement perpendicular to hydrant location using e-bond epoxy adhesive 1240/1241 per manufacturer's specifications.

## 2.6 VALVE LOCATION MARKERS

- A. All valve locations and blow offs shall be marked with a concrete valve marker with a metal coin on top showing valve size, distance, and direction.

## 2.7 UNDERGROUND PIPE MARKERS

- A. Plastic Ribbon Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 3 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 2'-6" deep. Tape shall be Alarmtape by Paul Potter Associates, Detectatape by Allen Systems, Inc., Terra Tape by Griffolyn Co., Inc., or approved equal.
- B. Color: Blue
- C. Text: "CAUTION – WATER LINE BURIED BELOW".
- D. Detectable Tracer Wire: At all locations where pressure piping is installed and at lateral locations, non-ferrous or ferrous materials, the contractor shall install a continuous length of #12 solid copper wire, on top and parallel to the pipe

## 2.8 BEDDING AND COVER MATERIALS

- A. Bedding: NCDOT #57 or #67 stone.
  - 1. Install stone bedding only at the direction of the Town Public Utilities Department.
- B. Soil Backfill from Above Pipe to Finish Grade:
  - 1. For any trenches with water, sanitary, or storm sewer utilities that are not located under curb or paved areas, backfill using on-site suitable soil when available.
  - 2. For any trenches with water, sanitary, or storm sewer utilities that are located under curb or paved areas, backfill using only approved off-site select borrow.

## 2.9 ACCESSORIES

- A. Anchorages:
  - 1. Concrete Reaction Backing: Portland cement concrete mix, 3000 psi.
    - a. Cement: ASTM C 150, Type I.
    - b. Fine Aggregate: ASTM C33, sand.
    - c. Coarse Aggregate: ASTM C33, crushed gravel.
    - d. Water: Potable.
- B. Steel rods, bolt, lugs and brackets: ASTM A36/A36M or ASTM A307 carbon steel.
- C. Protective Coating: Bituminous coating.

## PART 3 EXECUTION

### 3.1 EXAMINATION AND PREPARATION

- A. Verify existing utility water main size, location, and inverts are as indicated on drawings.
- B. Pre-Construction Site Photos: (Recommended Only – NOT required).
  - 1. Take photographs along centerline of proposed pipe trench; minimum one photograph for each 50 feet of pipe trench.
  - 2. Show mail boxes, curbing, lawns, driveways, signs, culverts, and other existing site features.
  - 3. Include project description, date taken and sequential number on back of each photograph.
- C. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs. Use only equipment specifically designed for pipe cutting. The use of chisels or hand saws will not be permitted. Grind edges smooth with beveled end for push-on connections.
- D. Remove scale and dirt on inside and outside before assembly.
- E. Prepare pipe connections to equipment with flanges or unions.

### 3.2 BEDDING

- A. Excavate pipe trench in accordance with Section 31 23 17 for Work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated on Drawings.
- B. Dewater excavations to maintain dry conditions and preserve final grades at bottom of excavation.

- C. Provide sheeting and shoring in accordance with Section 31 23 17.

### 3.3 INSTALLATION - PIPE

- A. Install pipe in accordance with AWWA C600.
- B. Handle and assemble pipe in accordance with manufacturer's instructions and as indicated on drawings.
- C. Steel Rods, Bolt, Lugs, and Brackets: Coat buried steel with one coat of coal tar coating before backfilling.
- D. Lateral Separation of Sewers and Water Mains. Water mains shall be laid at least 10 feet laterally from existing or proposed sewers, unless local conditions or barriers prevent a 10-foot lateral separation—in which case:
  - 1. The water main is laid in a separate trench, with the elevation of the bottom of the water main at least 18 inches above the top of the sewer; or
  - 2. The water main is laid in the same trench as the sewer with the water main located at one side on a bench of undisturbed earth, and with the elevation of the bottom of the water main at least 18 inches above the top of the sewer.
  - 3. Crossing a Water Main Over a Sewer. Whenever it is necessary for a water main to cross over a sewer, the water main shall be laid at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer, unless local conditions or barriers prevent an 18 inch vertical separation in which case both the water main and sewer shall be constructed of ferrous materials and with joints that are equivalent to water main standards for a distance of 10 feet on each side of the point of crossing.
  - 4. Crossing a Water Main Under a Sewer. Whenever it is necessary for a water main to cross under a sewer, both the water main and the sewer shall be constructed of ferrous materials and with joints equivalent to water main standards for a distance of 10 feet on each side of the point of crossing. A section of water main pipe shall be centered at the point of crossing."
- E. Separation of Water Mains and Storm Drains:
  - 1. There shall be a minimum of 12" vertical separation between water mains and storm drain lines. The water main shall be covered with unopened bags of concrete mix. One bag shall be placed on the water main centered under the storm drain and one bag shall be placed on each side of the centered bag.
  - 2. There shall be a minimum of 12" horizontal separation between water mains and storm drain lines.
- F. Install ductile iron piping and fittings to AWWA C600.
- G. Torque applied to mechanical joint bolts shall be 75-90 ft/lb for joint sizes 4" to 24" in accordance with AWWA C600.

- H. Weld pipe in accordance with AWWA C206. Weld joints in accordance with AWWA C205.
- I. Flanged Joints: Not to be used in underground installations except within structures.
- J. Route pipe in straight line. Relay pipe that is out of alignment or grade.
- K. Install pipe with no high points. If unforeseen field conditions arise which necessitate high points, install air release valves as directed by Town Public Utilities Department.
- L. Install pipe to have bearing along entire length of pipe. Excavate bell holes to permit proper joint installation. Do not lay pipe in wet or frozen trench.
- M. Prevent foreign material from entering pipe during placement.
- N. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- O. Install pipe using a pipe joint lubricant (soap) that meets the requirements of NSF 61.
- P. Close pipe openings with watertight plugs during work stoppages.
- Q. Establish elevations of buried piping with not less than 36 inches of cover. Measure depth of cover from final surface grade to top of pipe barrel.
- R. Install copper tracer wire on top of all lines and lateral lines terminating to each valve box and meter box.
- S. Install plastic ribbon tape continuous buried 12 inches below finish grade.

### 3.4 INSTALLATION - VALVES AND HYDRANTS

- A. Install valves in conjunction with pipe laying; set valves plumb.
- B. Install hydrants; provide support blocking and drainage gravel; do not block drain hole.
  - 1. Set hydrants plumb with pumper nozzle facing roadway; set hydrants with centerline of pumper nozzle 18 inches above finished grade and safety flange not more than 6 inches nor less than 2 inches above grade.
  - 2. Paint hydrants in accordance with local color scheme.
  - 3. After hydrostatic testing, flush hydrants and check for proper drainage.

### 3.5 INSTALLATION - TAPPING SLEEVES AND VALVES

- A. Install tapping sleeves and valves in accordance with drawings and in accordance with manufacturer's instructions.

### 3.6 INSTALLATION – BACKFLOW PREVENTERS

- A. All backflow prevention shall be installed in accordance with the manufacturer's specifications.
- B. Backflow prevention assemblies shall be installed at a minimum height of 12 inches and a maximum height of 60 inches above the floor or ground. Assemblies shall also have a clear horizontal distance of 18 inches around the entire diameter of the device.
- C. All backflow prevention assemblies installed outside of buildings must be installed in an approved enclosure with the exception of residential lawn irrigation backflow prevention assemblies. All enclosures shall be insulated and shall meet the requirements of ASSE standard 1060.
- D. Double check valves and double detector check valves may be installed vertically with approval from the water department.
- E. Reduced pressure backflow prevention assemblies shall be installed only horizontally.
- F. All backflow preventers are required to be tested by a certified backflow prevention assembly tester within ten days of installation.

### 3.7 THRUST RESTRAINT

- A. Provide valves, tees, bends, caps, and plugs with concrete thrust blocks. Pour concrete thrust blocks against undisturbed earth. Poured concrete shall be ready mixed. Bagged concrete mixed on site will not be accepted. Locate thrust blocks at each elbow or change of pipe direction to resist resultant force and so pipe and fitting joints will be accessible for repair.
- B. Install tie rods, clamps, set screw retainer glands, or restrained joints. Protect metal restrained joint components against corrosion by applying a bituminous coating, or by concrete mortar encasement of metal area. Do not encase pipe and fitting joints to flanges.
- C. Install thrust blocks, tie rods, and joint restraint at dead ends of water main.
- D. All concrete thrust blocks shall set for a minimum of 36 hours before any load is applied.

### 3.8 LATERAL CONNECTIONS

- A. Install lateral connections in accordance with plans.

### 3.9 BACKFILLING

- A. Backfill in accordance with Section 31 23 17 – Trenching and Backfilling.

### 3.10 DISINFECTION OF POTABLE WATER PIPING SYSTEM

- A. Flush and disinfect system in accordance with Section 33 13 00.

### 3.11 FIELD QUALITY CONTROL

- A. Pressure test system to 150 psi. Repair leaks and re-test.
  - 1. After completion of pipeline installation, including backfill, but prior to final connection to existing system, conduct, in presence of Town Public Utilities Department, concurrent hydrostatic pressure and leakage tests in accordance with AWWA C600.
  - 2. Prior to pressure testing of buried piping, backfill shall have been placed and tamped to provide adequate support for all pipe and fittings, and reaction backing shall have been in place at least 5 days.
  - 3. Provide equipment required to perform leakage and hydrostatic pressure tests.
  - 4. Test Pressure: Not less than 150 psi or 50 psi in excess of maximum static pressure, whichever is greater.
  - 5. Conduct hydrostatic test for at least two-hour duration.
  - 6. No pipeline installation will be approved when pressure varies by more than 5 psi at completion of hydrostatic pressure test.
  - 7. Before applying test pressure, completely expel air from section of piping under test. Provide corporation cocks so air can be expelled as pipeline is filled with water. After air has been expelled, close corporation cocks and apply test pressure. At conclusion of tests, remove corporation cocks and plug the resulting piping openings.
  - 8. Slowly bring piping to test pressure and allow system to stabilize prior to conducting leakage test. Do not open or close valves at differential pressures above rated pressure.
  - 9. Examine exposed piping, fittings, valves, hydrants, and joints carefully during hydrostatic pressure test. Repair or replace damage or defective pipe, fittings, valves, hydrants, or joints discovered, following pressure test.
  - 10. No pipeline installation will be approved when leakage is greater than that determined by the following formula:

$L = (SD\sqrt{P})/148,200$
L = allowable, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches

P = average test pressure during leakage test, in pounds per square inch (gauge)
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11. When leakage exceeds specified acceptable rate, locate source and make repairs. Repeat test until specified leakage requirements are met.
- B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

END OF WATER UTILITY DISTRIBUTION

## **SECTION 331300 - DISINFECTING OF WATER DISTRIBUTION**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. The Proposal-Agreement Section of the Contract and other sections of this Division apply to the work in this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Disinfection of potable water distribution system
  - 2. Testing and reporting results.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Disinfection: No payment will be made for disinfection of water distribution piping. Cost of disinfection shall be included in the unit price bid for size and type of pipe material.

#### **1.4 REFERENCES**

- A. American Water Works Association:
  - 1. AWWA B303 - Sodium Chlorite.
  - 2. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
  - 3. AWWA C651 - Disinfecting Water Mains.

#### **1.5 SUBMITTALS**

- A. Product Data: Submit procedures, proposed chemicals, and treatment levels for review.
- B. Disinfection Report:
  - 1. Type and form of disinfectant used.
  - 2. Date and time of disinfectant injection start and time of completion.
  - 3. Test locations.
  - 4. Name of person collecting samples.
  - 5. Initial and 24-hour disinfectant residuals in treated water in ppm for each outlet tested.

6. Date and time of flushing start and completion.
7. Disinfectant residual after flushing in ppm for each outlet tested.

C. Bacteriological Report:

1. Date issued, project name, and testing laboratory name, address, and telephone number.
2. Time and date of water sample collection.
3. Name of person collecting samples.
4. Test locations.
5. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
6. Coliform bacteria test results for each outlet tested.

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with AWWA C651.

1.7 QUALIFICATIONS

- A. Testing Firm: For this project, the Contractor shall have all bacteriological testing done by a testing laboratory approved by the Albemarle Regional Health Department and The Currituck County Water Department.
- B. Submit bacteriologist's signature and authority associated with testing.

PART 2 PRODUCTS

2.1 DISINFECTION CHEMICALS

- A. Chemicals: AWWA B303, Sodium Chlorite.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

- A. Verify piping system has been cleaned, inspected, and pressure tested.
- B. Perform scheduling and disinfecting activity with start-up, water pressure testing, adjusting and balancing, demonstration procedures, including coordination with related systems.

### 3.2 INSTALLATION

- A. Before being placed into service, and before certification of completion by the Town Public Utilities Department, all new water systems, or extensions to existing systems or valved section of such extensions, or any replacement in the existing water system, or any exposed section of the existing system shall be disinfected, according to the requirements of the North Carolina Administrative Code Title 15A, Subchapter 18C, Section .1000.
- B. “.1001 DISINFECTION OF NEW SYSTEMS”
  - 1. All interior surfaces of new potable water supply systems, including wells, filters, storage tanks and distribution lines shall be thoroughly disinfected by means of hypochlorite or chlorine solutions, after which bacteriological test samples shall be collected.
  - 2. After disinfection the water supply shall not be placed into service until bacteriological test results of representative water samples analyzed in an approved laboratory are found to be satisfactory.”
- C. “.1003 DISINFECTION OF STORAGE TANKS AND DISTRIBUTION SYSTEMS”
  - 1. Water distribution systems, including storage tanks and water mains, after flushing to remove sediment and other foreign matter, and after testing for leaks, shall be disinfected by the addition and thorough dispersion of a chlorine solution in concentrations sufficient to produce a chlorine residual of at least 50 milligrams per liter (or ppm) in the water throughout the distribution system, including all water mains and storage tanks.
  - 2. The chlorine solution shall remain in contact with interior surfaces of the water system for a period of 24 hours. Then the water system shall be flushed with fresh water from an approved water source until the chlorine solution is dispelled. All piping systems shall be thoroughly flushed by providing a velocity of 2 feet per second in the line being flushed.
  - 3. Representative samples of the water shall then be collected when residual chlorine concentration is approximately 2 ppm. If bacteriological tests of the samples indicate that the water quality is satisfactory, the water mains and storage tanks may be placed in service.
  - 4. In unusual situations where large volume tanks are involved and where there is not sufficient water available to fill the tank or there is not available a suitable drainage area for the chlorinated water, an alternate disinfection procedure for tanks may be proposed. Such proposal must be submitted in writing completely describing the proposed disinfection procedure and substantiating the need for an alternate procedure in the particular circumstance. Such alternate procedure must be approved before being implemented. The conclusion of the department shall be final.”
- D. At locations where new water lines are to be tied into the existing system, the interior of all new fittings and valves required shall be bathed with a concentrated chlorine

solution at the time of installation. Water shall be flushed through the new valve a sufficient time to wash out the chlorine solution before closing the valve and installing additional pipe. The new valve shall remain closed until the new section of pipe to be installed has passed all tests.

- E. The Contractor shall be required to make arrangements for having tests conducted. All expenses incurred in making tests shall be borne by the Contractor and should be included in his bid per linear foot of pipe material.

### 3.3 FIELD QUALITY CONTROL

A. Disinfection and Flushing:

1. Disinfect pipeline installation in accordance with AWWA C651. Use of liquid chlorine is not permitted.
2. Upon completion of retention period required for disinfection, flush pipeline until chlorine concentration in water leaving pipeline is no higher than that generally prevailing in existing system or is acceptable for domestic use.
3. Legally dispose of chlorinated water. When chlorinated discharge may cause damage to environment, apply neutralizing chemical to chlorinated water to neutralize chlorine residual remaining in water.
4. Chlorine solution shall be collected in an approved container and dechlorinated using one of the following solutions or an approved equivalent: Sulfur Dioxide, Sodium Bisulfite, Sodium Sulfite, or Sodium Thiosulfate. Dechlorinated water shall be disposed of on site.

END OF DISINFECTION OF WATER DISTRIBUTION

## **SECTION 333000 - SANITARY SEWERAGE**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Town of Windsor Public Works Standards (latest Edition, Addenda, and approved materials list).
- C. Reference Specifications are referred to by abbreviation as follows:
  - 1. American National Standards Institute ANSI
  - 2. American Society for Testing and Materials ASTM
  - 3. American Water Works Association AWWA
  - 4. National Bureau of Standards NBS
  - 5. North Carolina Department of Transportation NCDOT
  - 6. North Carolina Department of Health NCDH
  - 7. North Carolina Department of Environmental Quality NCDEQ

#### **1.2 SUMMARY**

- A. This Section includes sanitary sewerage system piping and appurtenances from a point 5 feet outside the building to the point of disposal or to the connection point into the existing municipal wastewater system.

#### **1.3 SUBMITTALS**

- A. Submit shop drawings and/or product data for the following:
  - 1. Pipe and pipe lining
  - 2. Fittings
  - 3. Special Pipe Couplings
  - 4. Manholes and Accessories
    - a. Flexible pipe connectors
    - b. Rings and covers
    - c. Adjusting rings
    - d. Entry seals
    - e. Vent piping
    - f. Frame-to-manhole sealant
    - g. Steps

- h. Exterior coatings
    - i. Interior protective linings and coatings
  - 5. Steel Encasement Pipe
  - 6. Casing Spacers and End-seals
  - 7. Detectable Marking Tape
  - 8. Tracing Wire
  - 9. Cleanouts
  - 10. Bedding Stone
- B. Certification provided by the contractor that all materials and sewage piping have been tested and meet the provisions of the contract documents.

#### 1.4 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems, and to the requirements of the latest edition of the North Carolina Erosion and Sediment Control Planning and Design Manual for erosion control during installation.
- B. Utility Compliance: Comply with the requirements of Town of Hertford Public Works Standards (latest Edition, Addenda, and approved materials list).

#### 1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Prepare materials for shipping and transport as follows:
  - 1. Ensure materials are dry and internally protected against rust and corrosion.
  - 2. Protect materials against damage to threaded ends, flange faces, pipe bells and spigots, and coatings.
  - 3. Set materials in best position for handling to prevent rattling.
- B. Storage: Use the following precautions for materials during storage:
  - 1. Do not remove end protectors unless necessary for inspection and reinstall for storage.
  - 2. Protect materials from weather, moisture and dirt. If outdoor storage is necessary, elevate and support materials off the ground or pavement in watertight enclosures.
  - 3. Store pipe in accordance with manufacturer's recommendations. Do not store plastic structures, pipe, and fittings in direct sunlight. Support materials to prevent sagging and bending.
- C. Handling: Handle materials on-site to prevent damage.
  - 1. Handle materials to prevent interior and exterior coating and pipe-end damage, and to prevent the entrance of dirt, debris, and moisture.

2. Handle pre-cast concrete manholes and other structures according to manufacturer's written rigging instructions.
3. If any portion of piping and fittings is damaged, repairs should be made in accordance with manufacturer's recommendations prior to installation.

## 1.6 PROJECT CONDITIONS

- A. Site Information: Perform site survey to verify existing utility locations. Verify that sanitary sewerage system piping may be installed in compliance with the design and referenced standards.
- B. Locate existing structures and piping to be closed and abandoned.
- C. Existing Utilities: The location of existing utilities, including underground utilities, is indicated on the drawings insofar as their existence and location were known at the time of preparation of the drawings. However, nothing in these Contract Documents shall be construed as a guarantee that such utilities are in the location indicated or that they actually exist, or that other utilities are not within the area of operations. The Contractor shall make all necessary investigations to determine the existence and locations of such utilities far enough in advance of pipe laying to allow for adjustments due to conflicts in the horizontal and vertical positions of the pipeline.
  1. Do not proceed with utility interruptions without receiving Engineer's written permission.
  2. Notify Engineer not less than 48 hours in advance of proposed utility interruptions.
  3. Do not interrupt existing utilities serving facilities occupied by others except when permitted by the utility owner and after arranging to provide acceptable temporary utility services.
  4. Existing utilities across or along the line of work are indicated only in an approximate location. Locate all underground lines and structures. Call "NC One Call" at 811 prior to construction. If utilities are marked that are not shown on the plans, locate utility vertically and horizontally and provide information to Engineer. The contractor shall pay for any damage to and for maintenance and protection of existing utilities and structures.
- D. Connections to Existing System:
  1. Before the start of the construction, the Contractor shall dig test pits on all crossings of and connections to the existing system, as applicable, to determine the existing system location, size, and piping material. If the location, size, and piping material differs from that shown on the Drawings, notify Engineer immediately.
  2. The Contractor shall make connections to the existing system under a pressure or non-pressure condition, as indicated, complying with the system owner's requirements for the time of day such work can be done. The Contractor shall pay all costs associated with the connections unless otherwise indicated. If the

system owner performs the work, the Contractor shall arrange for the work to be done.

3. Valves are to be operated only by the Owner.

## 1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with other utility work.
- B. Utility interruptions shall be coordinated with local utility provider. Written notice 48 hours in advance of utility interruption shall be provided to all affected customers.

## PART 2 - PRODUCTS

### 2.1 PIPE AND PIPE LINING

- A. General: Provide pipe materials and fittings compatible with each other.
- B. Gravity Sewer Pipe:
  1. Polyvinylchloride (PVC) Sewer (as indicated on the plans):
    - a. Polyvinylchloride (PVC) non-pressure pipe (4"-6") SCH 40 PVC bell and spigot style solvent weld pipe meetin requirements of ASTM D1785 may be used for service laterals.
    - b. Polyvinylchloride (PVC) non-pressure pipe (6"-15") shall meet requirements of ASTM D3034, Type PSM, SDR-35 or SDR-26 with elastomeric gasket joints meeting requirements of ASTM D3212. Bedding shall be as shown on the construction plans.
    - c. Polyvinylchloride (PVC) non-pressure pipe (18"- 24") shall meet requirements of ASTM F679, Table I, Type SDR-26 for large diameter solid wall PVC pipe with elastomeric gasket joints meeting requirements of ASTM D3212. Cell classification for sewer pipe shall be 12454-B or 12364-C. Bedding shall be as shown on the construction plans.
  2. Ductile Iron (DI) Sewer:
    - a. Ductile iron (DI) non-pressure pipe shall meet requirements of AWWA C151. Pipe shall be thickness Class 52. Pipe shall have cement-mortar lining and a bituminous seal coat. Thickness classes shall meet requirement of AWWA C150.
    - b. Mechanical joints and jointing material shall meet requirements of AWWA/ANSI C111/A21.11.
    - c. Flanged joints for ductile iron pipe shall meet requirements of ANSI B16.1. Flanged joint gaskets shall be full face, made of 1/16-inch thick rubber, and shall meet the requirements of ANSI B16.21.
    - d. Push on joint and rubber gasket shall meet requirements of AWWA C111.

- e. Cement mortar lining with bituminous seal coat for ductile iron pipe and fittings shall meet requirements of AWWA/ANSI C104/A21.4.
- f. Cement mortar lining shall be standard thickness.
- g. Exterior, bituminous coating for ductile iron pipe shall meet requirements of AWWA/ANSI C106/A21.6 or AWWA/ANSI C151/A21.51 as applicable.

## 2.2 FITTINGS

- A. General: Provide pipe fitting materials compatible with each other.
- B. Polyvinylchloride (PVC) Gravity Sewer:
  - 1. Polyvinylchloride (PVC) non-pressure fittings (4"-15") shall meet requirements of ASTM D3034, Type PSM, SDR-35 with elastomeric gasket joints meeting requirements of ASTM D3212.
  - 2. Polyvinylchloride (PVC) non-pressure fittings (18"- 24") shall meet requirements of ASTM F679, Table I Type SDR-35 for large diameter solid wall PVC pipe with elastomeric gasket joints meeting requirements of ASTM D3212.
- C. Ductile Iron (DI) Gravity Sewer:
  - 1. Fittings shall be ductile iron. Ductile iron fittings shall meet requirements of AWWA C110. Pressure ratings shall be a minimum of 350 psi for all fittings. Fittings shall have cement-mortar lining and a bituminous seal coat.
  - 2. Gaskets: ASTM F 477, elastomeric seal.
  - 3. Standard-Pattern, Ductile-Iron Fittings: AWWA C110, for push-on joints.
  - 4. Compact-Pattern, Ductile-Iron Fittings: AWWA C153, for push-on joints.
  - 5. Fitting Interior Coating: AWWA C104, asphaltic-material seal coat.
  - 6. Mechanical joints and jointing materials shall meet requirements of AWWA C111.
    - a. Mechanical joint retainer glands shall meet requirements of AWWA C111. Retainer gland shall be fitted with setscrews.
    - b. Metal harness shall be galvanized rods and clamps as detailed on Drawings.
    - c. Provide systems called for (or equals) as required on the drawings for restrained joints on aerial pipe.
- D. Sewer Saddles:
  - 1. Applies to taps for service lines of 4 inches or 6 inches on main line pipe up to 12 inches.
  - 2. Straps shall be stainless steel, 24-gauge, 2.5 inches wide
  - 3. Nuts and bolts shall be stainless steel, 3/8-inch diameter.
  - 4. Saddle shall be coated cast iron, with tubular rubber gasket.
  - 5. Adapter compatible with service line shall be secured to saddle with PVC sleeve.
  - 6. Sewer saddles shall be as manufactured by one of the following:

- a. ROMAC Industries, Inc
- b. GENCO (The General Engineering Co.)
- c. Inserta Fittings Company

## 2.3 SPECIAL PIPE COUPLINGS

- A. Use flexible pipe couplings where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.
  - 1. Use the following pipe couplings for non-pressure applications:
    - a. Sleeve type to join piping, of same size, or with small difference in OD.
    - b. Increaser/reducer-pattern, sleeve type to join piping of different sizes. Sleeve type shall be of the eccentric pattern.

## 2.4 MANHOLES AND ACCESSORIES

- A. General
  - 1. Manholes shall be constructed of pre-cast reinforced concrete manhole sections in accordance with the requirements of ASTM C478, NCDOT and detailed on the construction plans.
  - 2. A maximum of two lift holes per manhole section may be provided.
  - 3. Provide tongue and groove joints in manhole sections with a preformed groove in the tongue for placement of an O-ring type round, rubber gasket, or butyl rubber sealant.
- B. Flexible Pipe Connectors: Provide flexible pipe connections to manholes, other than acid-resistant manholes, for pipes 24 inches and smaller in size.
  - 1. Materials shall be resistant to water, sewage, acids, ozone, weathering and aging. Connectors shall conform to the requirements of ASTM C923. Use neoprene conforming to ASTM C443 and stainless steel, Series 300.
  - 2. Cast or core drill openings in manholes to receive connectors. Connectors shall be suitable for field repair or replacement. Connectors not suitable for field replacement are unacceptable.
  - 3. The assembled connectors shall allow at least an 11° angular deflection of the pipe and at least one inch of lateral misalignment in any direction and be suitable for a normal variation in diameter or roundness for the pipe material used.
  - 4. Connectors shall be similar to Kor-N-Seal as manufactured by NPC, Inc.
- C. Frames and Covers: Manhole frames and covers shall be molded of gray cast iron conforming to ASTM A48, Class 30. Castings shall be coated with a coal tar pitch varnish, to which sufficient oil has been added to make a smooth coating that is not tacky or brittle. Seating surfaces between frame and cover shall be machined. Manhole frame and covers shall be one of the following, or equivalent:

1. Street Type
    - a. Neenah Foundry
    - b. Capitol Foundry
    - c. Sigma Corporation
    - d. East Jordan Iron Works
  2. Watertight
    - a. Capitol Foundry
    - b. East Jordan Iron Works
  3. Vandal Proof
    - a. Neenah Foundry
    - b. Capitol Foundry
- D. Adjusting Rings: Adjusting rings shall be made of reinforced concrete. Brick, block and mortar construction shall not be permitted in lieu of rings. Rings shall be of required thickness to obtain the desired top elevation and match the diameter of the frame and cover. Any combination of adjustment rings shall not exceed a total thickness of 9 inches.
- E. Vent Piping: Vent piping shall be installed in accordance with the details shown on the construction drawings.
- F. Steps: Manhole steps shall be corrosion-resistant and shall be one-half inch grade 60 steel reinforcing rod encapsulated in a copolymer polypropylene. The steps shall conform with ASTM C478 paragraph 11 and shall have a minimum width of 12" and shall project a minimum of 5" from the manhole wall.

## 2.5 DETECTABLE MARKING TAPE

- A. Detectable marking tape shall be installed above all gravity sewer (including all service laterals).
- B. Plastic marking tape shall consist of one layer of aluminum foil laminated between two layers of inert plastic film. Tape shall be resistant to alkalis, acids and other destructive agents commonly found in the soil. The laminate shall be strong enough that the layers cannot be separated by hand.
- C. Tape shall be a minimum of 4-1/2 mils thick with a minimum tensile strength of 60 lbs. in the machine direction and 58 lbs. in the transverse direction per 6" wide strip. Tape color shall be APWA Color Coded for marking the particular utility line and shall be imprinted with a continuous warning message to indicate the type of utility being marked, the message normally being repeated every 16" to 36". Tape shall be inductively locatable and conductively traceable using a standard pipe and cable-

locating device. Tape shall be 6" wide by Omega Marking, Terra Tape, or approved equivalent.

## 2.6 TRACING WIRE

- A. Tracing Wire shall be installed on all plastic sewer piping (including all service laterals).
- B. Wire shall be No. 12, stranded, type THHN, thermoplastic insulated and nylon jacketed. Wire shall be color coded green for sewer.
- C. Access shall be provided to the tracer wire or the tracer wire shall terminate at the cleanout between the building drain and building sewer.
- D. Acceptable Wire Connectors:
  - 1. Set screw pressure type for use with No. 12 stranded wire size. Holub Industries MA-2, Ideal Industries Model 30-222, or approved equal.
  - 2. C-Tap for two way splicing of tracer wire, for use with No. 12 stranded wire size. T&B #54705 or approved equal.
  - 3. Split bolts, three wire type for splicing of tracer wire, for use with No. 12 stranded wire size ILSCO Catalog #SEL-2S or approved equal.

## 2.7 CLEANOUTS

- A. General:
  - 1. In Pavement: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame heavy-duty, secured, scoriated cast-iron cover.
  - 2. In Grass: Provide SCH 40 PVC threaded fitting and plug.
- B. Sewer pipe fitting and riser to cleanout shall be the same material as the run of pipe for which it serves.

## PART 3 – EXECUTION

### 3.1 SEPARATION OF WATER LINES AND SANITARY SEWERS

- A. Follow NCDEQ for the separation of sanitary sewer and water distribution systems.
- B. Parallel Installation
  - 1. Normal Conditions - Sewer lines and manholes shall be constructed at least 10 feet horizontally from a waterline whenever possible. The distance shall be measured edge-to-edge.
  - 2. Unusual Conditions - When local conditions prevent a horizontal separation of at least 10 feet, then maximum horizontal separation shall be provided with vertical separation of bottom of waterline at least 18 inches above top of sewer. Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA approved water pipe pressure-tested in place to 5 psi without leakage

prior to backfilling. The sewer manhole shall be of watertight construction and tested in place.

C. Crossing:

1. Normal Conditions - Sewers crossing under waterlines shall be laid to provide a separation of at least 18 inches between the bottom of the waterline and the top of the sewer whenever possible.
2. Unusual Conditions - When local conditions prevent a vertical separation described in Crossing, Normal Conditions, paragraph above, the following construction shall be used:
  - a. Sewers passing over or under waterlines shall be constructed of ductile iron pipe with mechanical joints as described in Parallel Installation, Unusual Conditions above.
  - b. Sewers passing over waterlines shall be laid to provide:
    - 1) Adequate structural support for the sewers to prevent excessive deflection of the joints and settling on and breaking waterline.
    - 2) Maximum separation of water and sewer line joints.

- D. Sanitary and sewers or sewer manholes - No water pipes shall pass through or come in contact with any part of a sewer or sewer manhole.

### 3.2 EXCAVATING AND BACKFILLING

- A. See Section 31 2317 "Trenching and Backfilling".
- B. Excavation, trenching, backfilling and bedding for all piping specified herein shall conform to the applicable requirements of the NCDOT Standard Specifications for Roads and Structures and/or to details shown on the construction plans.
- C. Remove any and all materials encountered in the course of excavating for all underground utility systems. After the pipe is in place, backfill with suitable material, free from frozen earth, rocks, and organic materials.
  1. Provide all necessary shoring required for the protection of excavations, existing utilities and workmen and do all necessary pumping required to keep excavation and pipe free from water from any source at all times.
  2. Provide sufficient barricades adjacent to excavations to safeguard against injury to workmen and the public. Provide and maintain sufficient warning lanterns at walks, roadways, and parking areas to provide safety at all times.
  3. Where roots of live trees are encountered in excavations, they shall be carefully protected during construction.
  4. Exercise special care in backfilling trenches to guard against disturbing the joints.
  5. Remove and dispose of any material not used for backfill.

- D. Removal of subsurface obstructions which are uncovered during excavation for installation of the sanitary sewer systems shall be by the Contractor at his expense. This shall include removal of existing concrete or brick from existing building foundations, footings, abandoned utility piping, wires, structures, rock boulders, etc., which may not be visible from surface investigations before construction, but will interfere with new installations. If such obstructions are encountered, they shall be removed two feet from around the area of new work and the excavation backfilled with a suitable material as specified.

### 3.3 PIPE HANDLING

- A. Take all precautions to ensure that pipe, fittings, and related items are not damaged in unloading, handling and placing in trench. Examine each piece of material just prior to installations to determine that no damage has occurred. Remove any damaged material from the site and replace with undamaged material.
- B. Keep pipe clean. Exercise care to keep foreign material and dirt from entering pipe during storage, handling and placing in trench. Close ends of in-place pipe at the end of any work period to prevent entry of animals and foreign material.
- C. Survey Line and Grade
  - 1. Line and grade hubs shall be set by a registered surveyor, maintained by the Contractor, and the Engineer provided with cut-sheets.
  - 2. Contractor shall have level or transit in good working order on the job set up at all times to periodically check line and grade of pipe.

### 3.4 GRAVITY SEWER PIPE LAYING

- A. Laying of sewer pipe shall be accomplished to line and grade as indicated on the contract drawings and in the trench only after it has been dewatered and the foundation and/or bedding has been prepared. Mud, silt, gravel, and other foreign material shall be kept out of the pipe and off the jointing surfaces. Do not lay pipe when weather or trench conditions are unsuitable.
- B. Pipe and fittings shall be strung out along the route of construction with the bells facing in the direction in which the work is to proceed. Pipe shall be placed where it will cause the least interference with traffic. Laying of the pipe shall be commenced immediately after the excavation is started and every means must be used to keep pipe laying closely behind the trenching. The Engineer may stop the trenching when, in his opinion, the trench is open too far in advance of the pipe laying operation. The bottom of the sewer trench shall be shaped to give substantially uniform circumferential support to the lower on-third of each pipe. Holes shall be scooped out where the bells occur leaving the entire barrel of the pipe bearing on the pipe bed.
- C. All pipe laid shall be retained in position so as to maintain alignment and joint closure until sufficient backfill has been completed to adequately hold the pipe in place. All

pipe shall be laid to conform to the prescribed line and grade shown on the contract drawings. After completion the pipe shall exhibit a full circle of light at one manhole when viewed from the next.

- D. The sewer pipe shall be laid upgrade from point of connection to the existing sewer or from a designated starting point. If the starting point is at an existing stub, it shall be removed and a full length of pipe installed. The sewer pipe shall be installed with the bell end forward or upgrade. When pipe laying is not in progress, the forward end of the pipe shall be kept tightly closed with a watertight plug or cap. When the upstream end of a sewer does not terminate at a manhole, it shall be plugged and its location marked in a manner approved by the Inspector.
- E. The pipe shall be fitted and matched so that when installed it will form a smooth, uniform invert.
- F. Prior to joining the pipe, all surfaces of the pipe to be joined and the surfaces of factory made jointing materials shall be clean and dry. Lubricants, primers, adhesives, etc., shall be applied and the pipes joined as recommended by the manufacturer's specifications. Sufficient pressure shall be applied in making the joint to assure that the pipe is "home". The interior of the pipe shall be cleaned of all foreign material as the work progresses. At the end of the workday, the last pipe laid shall be blocked to prevent creep, and closed with a watertight plug or cap.
- G. Joining Pipe
  - 1. Ductile iron pipe is to be joined in accordance with the requirements of AWWA Standard C600 and the manufacturer's recommendations.
  - 2. Polyvinyl chloride (PVC) pipe shall be joined in accordance with ASTM Standard D-2321.
  - 3. Other type pipe shall be joined in accordance with the manufacturer's recommendations and the requirements of the County approved plans and specifications.
- H. All visible leaks shall be corrected prior to testing.

### 3.5 MANHOLES

- A. Manholes shall be constructed to the elevations shown on the Contract Drawings in accordance with the provisions of the Standard Details.
- B. Set manhole base section on bed of NCDOT #57 or #67 stone to a minimum depth of 8 in. Stone shall be thoroughly compacted and carefully leveled to the excavated earth wall.
- C. Join all manhole riser and cone or flat slab top sections by the use of an approved butyl rubber sealant.

- D. Pack and brush joints in FRP lining in acid-resistant manholes with sealant to provide a watertight and acid-resistant seal. Field weld joints in PVC lining of acid-resistant manholes in accordance with manufacturer's instructions.
- E. Install pipe stubs in manholes where called for on the Contract Drawings. All stubs shall be sealed watertight with a plug or cap at both ends.
- F. Install flexible manhole connections for all pipes sizes 4 in. to 24 in., inclusive, and apply sealant to completely fill joint between manhole barrel and flexible connection for the full thickness of the manhole barrel.
- G. Plug lift holes and repair any defects in manhole.
- H. Adjusting Rings: Include two or three adjusting rings, of 6-to-9-inch total thickness that match diameter of frame and cover.
- I. Set manhole frame in bed of sealant. Bed shall consist of one, 3/8 in. bead laid flush with the inside edge of the frame base and another 3/8 in. bead laid flush with the outside edge of the frame base.
- J. Construct bench of concrete or brick and mortar.
  - 1. Lowest elevation of bench shall be at the spring line of the outgoing pipe.
  - 2. Slope bench three inches toward channel for drainage.
  - 3. Where stubs or knockouts are provided for future pipe connections, bench shall be so formed.
  - 4. Use sulfate resistant cement for concrete or mortar on all acid-resistant manholes.
  - 5. Where sealant is used, bench shall not be in contact with pipe or flexible pipe connection.
- K. Existing Manhole Tie-In
  - 1. Core drilling and a flexible pipe-to-manhole connector shall be used in the connection of the sewer pipe to precast manholes, where stubs or bricked up opening do no exist.
  - 2. The connector shall be Kor-N-Seal assembly or approved equal.
  - 3. The connector shall be installed in the manhole wall by activating the expanding mechanism in strict accordance with the recommendation of the connector manufacturer.
  - 4. The connector shall be of a size specifically designed for the pipe material and size being utilized on the project. All materials must conform to the approved products reflected in these standards.
  - 5. Where bricked up opening exists, a PVC manhole adapter shall be used in the connection of the sewer pipe to precise manholes and installed using the proper conventional methods such as the process established for the "GPK PVC Manhole Adapters" or approved equal.

### 3.6 DETECTABLE MARKING TAPE

- A. Install detectable marking tape in all trenches containing buried, non-metallic, pipelines. Tape shall be installed in all trenches with a cover of 18" to 36" and a minimum clearance over the pipelines of 18".

### 3.7 ROAD/HIGHWAY CROSSINGS

- A. Where crossing is to be installed beneath a North Carolina road or highway, all operations and materials shall conform to the requirements of the North Carolina Department of Transportation governing such crossings, and the contractor shall obtain approval of all materials and methods to be employed before such work is started. A copy of such permission shall be filed with the Owner prior to starting the work. The contractor will also be required to furnish a release from the proper authorities before final acceptance of the work by the Owner. The contractor shall secure from the Department of Transportation the necessary information regarding proper bracing, sheeting, shoring and other required protection of the highway and traffic during the construction operation. Where an open cut is permissible in crossing the State Highway instead of boring, the contractor shall make the necessary provisions for handling traffic and replacing the roadbed and surface as required by the North Carolina Department of Transportation. Contractor shall be responsible for the payment of all fees required to obtain the necessary permits

### 3.8 CLEAN UP

- A. Upon the completion of the installation of the sanitary sewer system and prior to acceptance, sediment and debris shall be removed from the limits of construction. All trash and debris shall be removed and properly disposed of. Areas not otherwise stabilized shall be seeded and mulched and a good stand of grass established.

## PART 4 -TESTING

### B. GRAVITY SEWERS

1. Testing of gravity sewer lines shall be conducted on short sections of sewer line, i.e., between manholes. Provide all labor, materials, tools, and equipment necessary to make the tests, and ensure that zero infiltration is provided. All equipment and methods used shall be acceptable to the Engineer and the Owner. All monitoring gages shall be subject to calibration, if deemed necessary.
2. Sanitary sewer lines 24 in. diameter and smaller shall be tested after backfill using a low-pressure air test in accordance with ASTM C924.
3. Summary of Method: Plug the section of the sewer line to be tested. One of the plugs used at the manhole must be tapped and equipped for the air inlet connection for filling the line from the air compressor. Introduce low-pressure air

- into the plugged line. Use the quantity and rate of air loss to determine the acceptability of the section being tested.
4. Preparation of the sewer line: Flush and clean the sewer line prior to testing, thus serving to wet the pipe surface as well as clean out any debris. A wetted interior pipe surface will produce more consistent results. Plug all pipe outlets using approved pneumatic plugs with a sealing length equal to or greater than the diameter of the line being tested to resist the test pressure. Give special attention to laterals.
  5. Groundwater Determination: Install a ½-inch capped galvanized pipe nipple, approximately 12 inches long, through the manhole on top of the lowest sewer line in the manhole. Immediately prior to the line acceptance test, the ground water elevation shall be determined by removing the pipe cap and blowing air through the pipe nipple into the ground so as to clear it, and then connecting a clear plastic hose to the pipe nipple. The hose shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in the plastic hose.
  6. Procedures: Determine the test duration for the section under test by computation from the applicable formulas shown in ASTM C828. The pressure-holding time is based on an average holding pressure of 3 psi gage or a drop from 3.5 psi to 2.5 psi gage.
    - a. Add air until the internal air pressure of the sewer line is raised to approximately 4.0 psi gage. After an internal pressure of approximately 4.0 psig is obtained, allow time for the air pressure to stabilize. The pressure will normally show some drop until the temperature of the air in the test section stabilizes.
    - b.
    - c. If the pipe to be tested is submerged in ground water, the test pressure shall be increased to 1.0 psi for every 2.31 feet the ground water level is above the invert of the sewer. In no case shall the pressure exceed 10 psig.
    - d. When the pressure has stabilized and is at or above the starting test pressure, commence the test. Before starting the test, the pressure may be allowed to drop by 0.5 psig. Record the drop in pressure for the test period. If the pressure has dropped more than 0.5 psi gage during the test period, the line shall be presumed to have failed. The test may be discontinued when the prescribed test time has been completed even though the 0.5 psig drop has not occurred.
    - e. The test procedure may be used as a presumptive test, which enables the installer to determine the acceptability of the line prior to backfill and subsequent construction activities.
  7. Safety: The air test may be dangerous if, because of lack of understanding or carelessness, a line is improperly prepared.
    - a. It is extremely important that the various plugs be installed and braced in such a way as to prevent blowouts. In as much as a force of 250 lbs. is exerted on an 8 inch plug by an internal pipe pressure of 5 psi, it should be realized that sudden expulsion of a poorly installed plug or of a plug that is partially deflated before the pipe pressure is released can be dangerous.

- b. As a safety precaution, pressurized equipment shall include a regulator or relief valve set at perhaps 10 psi to avoid over-pressurizing and damaging an otherwise acceptable line. No one shall be allowed in the manholes during testing.

### C. MANHOLES

1. Vacuum testing of manholes: Vacuum tests shall be conducted on newly constructed manholes following construction and after all connections have been made but before any backfilling around the manhole. Successful testing shall be accomplished before any backfilling operations.
2. Provide necessary vacuum pump, pneumatic plugs and accessories required for proper performance of the test. Plugs shall have a sealing strength equal to or greater than the diameter of the connecting pipe to be sealed.
3. Follow all local, state and federal safety precautions. Brace inverts if lines entering the manhole have not been backfilled or otherwise restrained to prevent pipe from being dislodged and pulled into the manhole.
4. Install vacuum tester head assembly at the top access of the manhole. Adjust the cross brace to insure that the inflatable sealing element inflates and seals against the straight top section of the manhole if possible.
5. Attach the vacuum pump assembly to the proper connection on the test head assembly. Make sure the vacuum inlet/outlet valve is in the closed position.
6. Following safety precautions and testing equipment manufacturer's instructions, inflate sealing element to the recommended maximum inflation pressure. Do not over-inflate.
7. Start the vacuum pump assembly engine and allow preset pump to stabilize. Open the inlet/outlet ball valve and evacuate the manhole to 10" Hg (approximately - 5 psig). Pressurizing the manhole may result in damage to manhole or to test equipment.
8. Close vacuum inlet/outlet ball valve and monitor vacuum for specified test period (see table). If vacuum does not drop in excess of 1" Hg., manhole is considered acceptable and the manhole passes the test. If manhole fails the test, complete necessary repairs and repeat test procedures until satisfactory results are obtained.

#### 4-FT. DIAMETER MANHOLE

<u>Manhole Depth</u>	<u>Minimum Elapsed Time for a Pressure Change of 1 Inch Hg</u>
10 Ft. or Less	60 Seconds
Greater Than 10 Ft. But Less Than 15 Ft.	75 Seconds
Greater than 15 Ft. But Less Than 25 Ft.	90 Seconds
Greater Than 25 Ft.	Add 2 Seconds Per Foot of Additional Manhole Depth.

For manholes five feet in diameter, add an Additional 15 seconds, and for manholes six feet in diameter, add an Additional 30 seconds to the time required for four-foot diameter manholes.

9. Repeat the above test procedure after backfilling manhole for final acceptance test.

END OF SANITARY SEWERAGE

## **SECTION 333200 – WASTEWATER PUMP STATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS:**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Submersible effluent pumps.
  - 2. Sewage-pump basins and basin covers.
  - 3. Pump controls.

#### **1.3 SUBMITTALS:**

- A. Shop Drawings: Show size, materials, and components of system. Indicate basin size, inlet and discharge location, cover dimensions, and vent location. Provide fabrication drawings from pre-cast manufacturer.
- B. Product Data:
  - 1. Include catalog data for basin, cover, slide rail assembly, discharge piping, valves, level controls, and control panel.
  - 2. Include pump catalog data, performance curve, breakaway fittings data, and access frame data.
  - 3. Include control panel data and panel wiring schematic.
- C. Manufacturer's Installation Instructions: Submit manufacturer's published installation instructions.
- D. Submit executed certification of pumping stations after performance testing.
- E. Provide Operations and Maintenance Manual containing operating and maintenance requirements for pumping station and schedule of recommended maintenance.

#### 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.
- C. All work shall conform to applicable AWWA and ASTM standards and the manufacturer's recommendations and instructions.

#### 1.5 MANUFACTURER:

- A. The Contractor shall be responsible for the satisfactory operation of the entire system. The equipment specified shall be a product of a company experienced in the design and manufacture of grinder pumps for specific use in pressure sewage systems. The company shall submit detailed installation and user instructions for its product, submit evidence of an established service program including complete parts and service manuals, and be responsible for maintaining a continuing inventory of grinder pump replacement parts.

#### 1.6 INSTALLER QUALIFICATIONS

- A. Installer shall be a licensed underground utility contractor licensed for such work in the State of North Carolina. Installing contractor's license status shall be current.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- B. Protect piping from entry of foreign materials and water by temporary covers, completing sections of work, and isolating parts of completed system.
- C. Accept system components on site in manufacturer's original containers or configuration. Inspect for damage.
- D. Store sensitive materials for field assembly in dry area in original shipping containers.
- E. Support basin with nylon slings to structural lift points during handling.
- F. Repair damage to basin according to manufacturer's instructions.

## PART 2 PRODUCTS

### 2.1 SUBMERSIBLE PUMPS

- A. Electric Submersible Grinder Pumps:
  - 1. Basis of Design Product: Homa GRP 10/3
    - a. Alternatives by Barnes Pressure Systems, Zoeller Pump Company, Liberty Pumps or others meeting design requirements are acceptable.
  - 2. Furnish three (two for operation plus a spare) of each type of submersible pump specified.
- B. The pump shall be a custom designed, integral, vertical rotor, motor driven, solids handling pump of the progressing cavity type with a single mechanical seal. Double radial O-ring seals are required at all casting joints to minimize corrosion and create a protective barrier. All pump castings shall be cast iron, fully epoxy coated to 8-10 mil nominal dry thickness, wet applied. The rotor shall be through-hardened, highly polished, precipitation hardened stainless steel. The stator shall be of a specifically compounded ethylene propylene synthetic elastomer. This material shall be suitable for domestic wastewater service. Its physical properties shall include high tear and abrasion resistance, grease resistance, water and detergent resistance, temperature stability, excellent aging properties, and outstanding wear resistance. Buna-N is not acceptable as a stator material because it does not exhibit the properties as outlined above and required for wastewater service.

### 2.2 GRINDER:

- A. The grinder shall be placed immediately below the pumping elements and shall be direct-driven by a single, one-piece motor shaft. The grinder impeller (cutter wheel) assembly shall be securely fastened to the pump motor shaft by means of a threaded connection attaching the grinder impeller to the motor shaft. Attachment by means of pins or keys will not be acceptable. The grinder impeller shall be a one-piece, 4140 cutter wheel of the rotating type with inductively hardened cutter teeth. The cutter teeth shall be inductively hardened to Rockwell 50 - 60c for abrasion resistance. The shredder ring shall be of the stationary type and the material shall be white cast iron. The teeth shall be ground into the material to achieve effective grinding. The shredder ring shall have a staggered tooth pattern with only one edge engaged at a time, maximizing the cutting torque.
- B. The assembly shall be dynamically balanced and operate without objectionable noise or vibration over the entire range of recommended operating pressures. The grinder shall be constructed so as to minimize clogging and jamming under all normal operating conditions including starting. Sufficient vortex action shall be created to scour the tank free of deposits or sludge banks which would impair the operation of the pump. These requirements shall be accomplished by the following, in conjunction with the pump:
- C. The grinder shall be positioned in such a way that solids are fed in an upward flow direction.

- D. The maximum flow rate through the cutting mechanism must not exceed 4 feet per second. This is a critical design element to minimize jamming and as such must be adhered to.
- E. The inlet shroud shall have a diameter of no less than 5 inches. Inlet shrouds that are less than 5 inches in diameter will not be accepted due to their inability to maintain the specified 4 feet per second maximum inlet velocity which by design prevents unnecessary jamming of the cutter mechanism and minimizes blinding of the pump by large objects that block the inlet shroud.
- F. The impeller mechanism must rotate at a nominal speed of no greater than 1800 rpm.
- G. The grinder shall be capable of reducing all components in normal domestic sewage, including a reasonable amount of "foreign objects," such as paper, wood, plastic, glass, wipes, rubber and the like, to finely-divided particles which will pass freely through the passages of the pump and the 1-1/4" diameter stainless steel discharge piping.

## 2.3 ELECTRIC MOTOR:

- A. As a maximum, the motor shall be a 208 volt, 1 HP, 3450 RPM, capacitor start, ball bearing, air-cooled induction type with Class F installation, low starting current not to exceed 15 amperes. The motor shall be press-fit into the casting for better heat transfer and longer winding life. Inherent protection against running overloads or locked rotor conditions for the pump motor shall be provided by the use of an automatic-reset, integral thermal overload protector incorporated into the motor. This motor protector combination shall have been specifically investigated and listed by Underwriters Laboratories, Inc., for the application. Non-capacitor start motors or permanent split capacitor motors will not be accepted because of their reduced starting torque and consequent diminished grinding capability. The wet portion of the motor armature must be 300 Series stainless. To reduce the potential of environmental concerns, the expense of handling and disposing of oil, and the associated maintenance costs, oil-filled motors will not be accepted.

## 2.4 MECHANICAL SEAL:

- A. The pump/core shall be provided with a mechanical shaft seal to prevent leakage between the motor and pump. The seal shall have a stationary ceramic seat and carbon rotating surface with faces precision lapped and held in position by a stainless-steel spring.

## 2.5 TANK

- A. The tank shall be a wetwell design consisting of a single wall, laminated fiberglass construction. The resin used shall be of a commercial grade suitable for the environment. The reinforcing material shall be a commercial grade of glass fiber capable of bonding with the selected resin. The inner surface shall have a smooth finish and be free of cracks and crazing. The exterior tank surface shall be relatively smooth with no exposed fiber or sharp projections present.

- B. The tank wall and bottom shall be of sufficient thickness and construction to withstand the imposed loading due to saturated soil at the specified burial depth for each available tank height. All station components must function normally when exposed to the external soil and hydrostatic pressures developed at the specified burial depth. The tank bottom shall be reinforced with a fiberglass plate extending beyond the tank walls to support concrete anchoring, as required, to prevent flotation.
- C. The Fiberglass tank shall have a stainless-steel discharge bulkhead which terminates outside the tank wall with a 1-1/4" female pipe thread. The discharge bulkhead shall be factory installed and warranted by the manufacturer to be watertight. The tank shall be furnished with a field installed EPDM grommet to accept a 4.50" OD (4" DWV or SCH 40) inlet pipe.
- D. The power and control cable shall connect to the pump by means of the provided NEMA 6P Electrical Quick Disconnect (EQD) and shall enter the tank through a field installed watertight strain relief connector supplied by the manufacturer. An electrical junction box shall not be permitted in the tank. Installation of the inlet grommet and cable strain relief shall require field penetration of the tank wall by the installing party. The tank shall also be vented to prevent sewage gases from accumulating inside the tank by means of a factory-provided, field-installed mushroom vent. The station cover shall be factory drilled to accept the mushroom vent. The tank and stainless steel discharge bulkhead shall be factory-tested to be watertight.
- E. Consult the contract drawings for station tank sizes (diameter and height).

## 2.6 CHECK VALVE:

- A. The pump discharge shall be equipped with a factory installed, gravity operated, flapper-type integral check valve built into the stainless-steel discharge piping. The check valve will provide a full-ported passageway when open, and shall introduce a friction loss of less than 6 inches of water at maximum rated flow. Moving parts will be made of a 300 Series stainless steel and fabric reinforced synthetic elastomer to ensure corrosion resistance, dimensional stability, and fatigue strength. A nonmetallic hinge shall be an integral part of the flapper assembly providing a maximum degree of freedom to assure seating even at a very low back-pressure. The valve body shall be an injection molded part made of an engineered thermoplastic resin. The valve shall be rated for continuous operating pressure of 235 psi. Ball-type check valves are unacceptable due to their limited sealing capacity in slurry applications.

## 2.7 ANTI-SIPHON VALVE:

- A. The pump discharge shall be equipped with a factory-installed, gravity-operated, flapper-type integral anti-siphon valve built into the stainless-steel discharge piping. Moving parts will be made of 300 Series stainless steel and fabric-reinforced synthetic elastomer to ensure corrosion resistance, dimensional stability, and fatigue strength. A nonmetallic hinge shall be an integral part of the flapper assembly, providing a maximum degree of freedom to ensure proper operation even at a very low pressure. The valve body shall be injection-molded from an engineered thermoplastic resin. Holes or ports in the

discharge piping are not acceptable anti-siphon devices due to their tendency to clog from the solids in the slurry being pumped. The anti-siphon port diameter shall be no less than 60% of the inside diameter of the pump discharge piping.

## 2.8 CORE UNIT:

- A. The grinder pump station shall have a cartridge type, easily removable core assembly consisting of pump, motor, grinder, all motor controls, check valve, anti-siphon valve, level controls, and wiring. The core unit shall be installed in the basin by the manufacturer. Field assembly of the pump and controls into the basin is not acceptable. The core unit shall seal to the tank deck with a stainless-steel latch assembly. The latch assembly must be actuated utilizing a single quick release mechanism requiring no more than a half turn of a wrench. The watertight integrity of each core unit shall be established by a 100 percent factory test at a minimum of 5 PSIG.

## 2.9 CONTROLS:

- A. All necessary motor starting controls shall be located in the cast iron enclosure of the core unit secured by stainless steel fasteners. The controls shall also include a moisture detection sensor and a redundant pump starting circuit in the event of a high-level alarm. Locating the motor starting controls in a plastic enclosure is not acceptable. The wastewater level sensing controls shall be housed in a separate enclosure from motor starting controls. The level sensor housing must be sealed via a radial type seal; solvents or glues are not acceptable. The level sensing control housing must be integrally attached to pump assembly so that it may be removed from the station with the pump and in such a way as to minimize the potential for the accumulation of grease and debris accumulation, etc. The level sensing housing must be a high-impact thermoplastic copolymer over-molded with a thermo plastic elastomer. The use of PVC for the level sensing housing is not acceptable.
- B. Non-fouling wastewater level controls for controlling pump operation shall be accomplished by monitoring the pressure changes in an integral air column connected to a pressure switch. The air column shall be integrally molded from a thermoplastic elastomer suitable for use in wastewater and with excellent impact resistance. The air column shall have only a single connection between the water level being monitored and the pressure switch. Any connections are to be sealed radially with redundant O-rings. The level detection device shall have no moving parts in direct contact with the wastewater and shall be integral to the pump core assembly in a single, readily-exchanged unit. Depressing the push to run button must operate the pump even with the level sensor housing removed from the pump.
- C. The level control system shall be electrically connected to the motor controls using inductive means that requires no wiring between compartments. This control system shall be approved to comply with FM3610 Intrinsically Safe Controls. All fasteners throughout the assembly shall be 300 Series stainless steel. High-level sensing will be accomplished in the manner detailed above by a separate air column and pressure switch of the same type. Closure of the high-level sensing device will energize an alarm circuit as well as a redundant pump-on circuit. For increased reliability, pump ON/OFF

and high-level alarm functions shall not be controlled by the same switch. Float switches of any kind, including float trees, will not be accepted due to the periodic need to maintain (rinsing, cleaning) such devices and their tendency to malfunction because of incorrect wiring, tangling, grease buildup, and mechanical cord fatigue. To assure reliable operation of the pressure switches, each core shall be equipped with a factory installed equalizer diaphragm that compensates for any atmospheric pressure or temperature changes. Tube or piping runs outside of the station tank or into tank-mounted junction boxes providing pressure switch equalization will not be permitted due to their susceptibility to condensation, kinking, pinching, and insect infestation.

## 2.10 CONTROL PANEL:

- A. The grinder pump station shall include a NEMA 4X, UL-listed alarm panel suitable for wall or pole mounting. The NEMA 4X enclosure shall be manufactured of thermoplastic to ensure corrosion resistance. The enclosure shall include a hinged, lockable cover with padlock, preventing access to electrical components, and creating a secured safety front to allow access only to authorized personnel.
- B. The panel shall contain one 15-amp single pole circuit breaker for the alarm circuit and one 15-amp double pole circuit breaker per core for the power circuit. The panel shall contain a push-to-run feature, an internal run indicator, and a complete alarm circuit. All circuit boards in the alarm panel are to be protected with a conformal coating on both sides and the AC power circuit shall include an auto resetting fuse.
- C. The visual alarm lamp shall be inside a red, oblong lens at least 3.75" L x 2.38" W x 1.5" H. Visual alarm shall be mounted to the top of the enclosure in such a manner as to maintain NEMA 4X rating. The audible alarm shall be externally mounted on the bottom of the enclosure, capable of 93 dB @ 2 feet. The audible alarm shall be capable of being deactivated by depressing a push-type switch that is encapsulated in a weatherproof silicone boot and mounted on the bottom of the enclosure (push-to-silence button).
- D. The high-level alarm system shall operate as follows:
- E. The panel will go into alarm mode if either pump's alarm switch closes. During the initial alarm mode both pumps will run and the alarm light and buzzer will be delayed for a period of time based on user settings (default is 3-1/2 minutes). If the station is still in high-level alarm after the delay, the light and buzzer will be activated.
- F. The audible alarm may be silenced by means of the externally mounted push-to-silence button.
- G. The visual alarm remains illuminated until the sewage level in the wet well drops below the "off" setting of the alarm switch for both pumps.
- H. The entire alarm panel, as manufactured and including any of the following options shall be listed by Underwriters Laboratories, Inc.
- I. Service Equipment/Main Service Disconnect Breaker - A separate, internal breaker rated and approved for use as "service equipment" and acts as a main service disconnect of the grinder pump station shall be provided.

- J. Remote Sentry Indoor Alarm Module - A separate, remote indoor alarm module shall be provided to indicate a high-level alarm with or without AC power to the grinder pump station. The Remote Sentry indoor alarm module shall have an internal power source enabling its continued operation without AC power. The Remote Sentry shall have an audible alarm and a visual alarm, both of which shall automatically reset if the high-level alarm condition is eliminated. The Remote Sentry indoor alarm module shall include a Silence button for the audible alarm and a Test button.
- K. Run-time/Hour Meter - A run-time or hour meter to display the total run-time or operation time for the pump core shall be provided.
- L. Event/Cycle Counter - An event or cycle counter to display the number of operations of the pump core shall be provided.
- M. Wireless Cellular Based Communication Package - A cellular transmitter shall be used to communicate operating parameters, trouble conditions and high level alarm. Each panel shall be equipped with hardware that interfaces with the panel's circuit board assembly to obtain historical operating data and current system status. This information shall then be transmitted to a host system that utilizes an interactive website interface for end users to access the information. A secure user ID and password shall be used to provide access to the website. The website shall quickly identify sites that may be experiencing trouble and shall be able to generate reports including: running tallies of usage, flow rates, potential infiltration, predictive maintenance indicators and asset mapping/management. The website shall also provide a means to configure alerts corresponding to the various trouble conditions that can be sent to users via secure e-mail, SMS text, phone or an existing telemetry system. These alerts can be sent to any number of recipients. The unit shall be equipped with a battery that will allow one message to be sent out in the event of power loss. The communication package shall be a factory prewired unit within the panel enclosure including the compact cellular transmitter, power supply and antenna. Accessible data shall include:
  - 1. Pump run time
  - 2. Pump cycles
  - 3. Min, Max, Avg., and Last Runtime
  - 4. Min, Max, Avg. Operating Voltage, Wattage and Amperage
  - 5. Trouble Events
  - 6. High Level Alarm
  - 7. Brownout (low voltage)
  - 8. Overvoltage
  - 9. Run Dry (low wattage)
  - 10. Overpressure (high wattage)
  - 11. Excessive Runtime
  - 12. Alarm Circuit Fault
  - 13. Watt meter Fault
  - 14. Watt based Flow Rate Data
  - 15. Loss of Duplex Communication

## 2.11 SERVICEABILITY:

- A. The grinder pump core, including level sensor assembly, shall have two lifting hooks complete with lift-out harness connected to its top housing to facilitate easy core removal when necessary. The level sensor assembly must be easily removed from the pump assembly for service or replacement. A pump push-to-run feature will be provided for field trouble shooting. The push-to-run feature must operate the pump even if the level sensor assembly has been removed from the pump assembly. All motor control components shall be mounted on a readily replaceable bracket for ease of field service.

## 2.12 OSHA CONFINED SPACE:

- A. All maintenance tasks for the grinder pump station must be possible without entry into the grinder pump station (as per OSHA 1910.146, permit-required confined spaces). "Entry means the action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space."

## 2.13 SAFETY:

- A. The grinder pump shall be free from electrical and fire hazards as required. As evidence of compliance with this requirement, the completely assembled and wired grinder pump station shall be listed by ETL to Factory Mutual (FM) Standards for Class 1, Division 1, Group D, Intrinsically Safe or sometimes referred to as Class 1, Zone 1, to be safe and appropriate for the intended use.

## PART 3 EXECUTION

### 3.1 FACTORY TEST:

- A. Each grinder pump shall be submerged and operated for 1.5 minutes (minimum). Included in this procedure will be the testing of all ancillary components such as, the anti-siphon valve, check valve, discharge assembly and each unit's dedicated level controls and motor controls. All factory tests shall incorporate each of the above listed items. Actual appurtenances and controls which will be installed in the field shall be particular to the tested pump only. A common set of appurtenances and controls for all pumps is not acceptable. Certified test results shall be available upon request showing the operation of each grinder pump at two different points on its curve. Additional validation tests include: integral level control performance, continuity to ground and acoustic tests of the rotating components.
- B. The Engineer reserves the right to inspect such testing procedures with representatives of the Owner, at the manufacturer's facility.

### 3.2 CERTIFIED SERVICE PROGRAM:

- A. The grinder pump manufacturer shall provide a program implemented by the manufacturer's personnel as described in this specification to certify the service company as an authorized serviced center. As evidence of this, the manufacturer shall provide, when requested, sufficient evidence that they have maintained their own service department for a minimum of 30 years and currently employ a minimum of five employees specifically in the service department.
- B. As part of this program, the manufacturer shall evaluate the service technicians as well as the service organization annually. The service company will be authorized by the manufacturer to make independent warranty judgments. The areas covered by the program shall include, as a minimum:
  - 1. Pump Population Information - The service company will maintain a detailed database for the grinder pumps in the territory that tracks serial numbers by address.
  - 2. Inventory Management - The service company must maintain an appropriate level of inventory (pumps, tanks, panels, service parts, etc.) including regular inventory review and proper inventory labeling. Service technicians will also maintain appropriate parts inventory and spare core(s) on service vehicles.
  - 3. Service Personnel Certification - Service technicians will maintain their level-specific certification annually. The certifications are given in field troubleshooting, repair, and training.
  - 4. Service Documentation and Records - Start up sheets, service call records, and customer feedback will be recorded and available by the service company.
  - 5. Shop Organization - The service company will keep its service shop organized and pumps will be tagged with site information at all times. The shop will have all required equipment, a test tank, and cleaning tools necessary to service pumps properly.

### 3.3 DELIVERY:

- A. All grinder pump units shall be delivered to the job site 100 percent completely assembled, including testing, ready for installation. Field installation of the level sensor into the tank is not allowed.

### 3.4 INSTALLATION:

- A. Earth excavation and backfill are specified under site work, but are also to be done as a part of the work under this section, including any necessary sheeting and bracing.
- B. The Contractor shall be responsible for handling ground water to provide a firm, dry subgrade for the structure, and shall guard against flotation or other damage resulting from general water or flooding.
- C. Remove packing material. User's instructions must be given to the Owner. Hardware supplied with the unit, if required, will be used at installation. The basin will be supplied with a 6" inlet grommet for connecting the incoming 6" SDR 26 PVC sewer line.

Appropriate inlet piping must be used. The basin may not be dropped, rolled or laid on its side for any reason.

- D. Installation shall be accomplished so that 1" to 4" of access way, below the bottom of the lid, extends above the finished grade line. The finished grade shall slope away from the unit. The diameter of the excavated hole must be large enough to allow for the concrete anchor.
- E. A 6"-inch (minimum) layer of naturally rounded aggregate, clean and free flowing, with particle size of not less than 1/8" or more than 3/4" shall be used as bedding material under each unit.
- F. A concrete anti-flotation collar, sized according to the manufacturer's instructions, shall be provided and shall be pre-cast to the grinder pump. The grinder pump station with its pre-cast anti-flotation collar shall have a minimum of three lifting eyes for loading and unloading purposes.
- G. The electrical enclosure shall be furnished, installed and wired to the grinder pump station by the Contractor.
- H. The Contractor shall mount the alarm device in a conspicuous location, as per national and local codes. The alarm panel will be connected to the grinder pump station by a length of 6-conductor type SOOW cable. The power and alarm circuits must be on separate power circuits. The grinder pump stations will be provided with 75 feet of useable, electrical supply cable to connect the station to the alarm panel.

### 3.5 BACKFILL REQUIREMENTS:

- A. The excavation shall be backfilled with Class 1, angular crushed stone and topped with an 8" layer of topsoil, seeded and mulched.
- B. The site shall be restored to its original condition in all respects, including, but not limited to, curb and sidewalk replacement, landscaping, loaming and seeding, and restoration of the traveled ways, as directed by the Engineer.

### 3.6 START-UP AND FIELD TESTING:

- A. The Contractor shall provide the services of qualified factory trained technician(s) who shall inspect the placement and wiring of each station, perform field tests as specified herein, and instruct the Owner's personnel in the operation and maintenance of the equipment before the station is accepted by the Owner.
- B. All equipment and materials necessary to perform testing shall be the responsibility of the Contractor.
- C. Upon completion of the installation, the authorized factory technician(s) will perform the following test on each station:
  - 1. Make certain the discharge shut-off valve in the station is fully open.

2. Turn ON the alarm power circuit and verify the alarm is functioning properly.
  3. Turn ON the pump power circuit. Initiate the pump operation to verify automatic "on/off" controls are operative. The pump should immediately turn ON.
  4. Consult the Manufacturer's Service Manual for detailed start-up procedures.
- D. Upon completion of the start-up and testing, the Contractor shall submit to the Engineer the start-up authorization form describing the results of the tests performed for the grinder pump station. Final acceptance of the system will not occur until authorization forms have been received for the pump station installed and any installation deficiencies corrected.

### 3.7 OPERATION AND MAINTENANCE

#### A. Manuals

1. The Contractor shall supply three copies of Operation and Maintenance Manuals to the Owner, and one copy of the same to the Engineer.

END OF WASTERWTER PUMP STATION

## **SECTION 333400 – SANITARY SEWER FORCE MAINS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS:**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, Latest Edition.
- C. Reference Specifications are referred to by abbreviation as follows:
  - 1. American National Standards Institute                      ANSI
  - 2. National Sanitation Foundation                                NSF
  - 3. American Society for Testing and Materials                ASTM
  - 4. American Water Works Association                            AWWA
  - 5. Ductil Iron Pipe Research Association                        DIPRA
  - 6. North Carolina Department of Transportation                NCDOT

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Force mains.
  - 2. Bedding and cover materials.

#### **1.3 MEASUREMENT AND PAYMENT**

- A. Pipe and Fittings:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment includes:
    - a. Excavation,
    - b. Removal of unsuitable soil material from site,
    - c. Dewatering,
    - d. Shoring and bracing,
    - e. Piping and fittings,
    - f. Concrete thrust restraints,
    - g. Backfilling with suitable trench excavation or on-site suitable soil,
    - h. Testing.

#### 1.4 SUBMITTALS

- A. Product Data: Submit data on all pipe materials, pipe fittings, valves and accessories.
- B. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.
- C. Manufacturer's Certificate: Certify that products meet or exceed specifications.
- D. Record Documents (As-Built Drawings): Record location of pipe runs, connection, catch basins, cleanouts, and invert elevations. Identify and describe variations to drawings and discovery of unidentified buried objects.

#### 1.5 QUALITY ASSURANCE

- A. All work shall conform to applicable AWWA and ASTM standards as the manufacturer's recommendations and instructions.

#### 1.6 INSTALLER QUALIFICATIONS

- A. Installer shall be a licensed underground utility contractor licensed for such work in the State of North Carolina. Installing contractor's license status shall be current.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not place materials on private property without written permission of property owner.
- B. During loading, transporting and unloading, exercise care to prevent damage to materials.
- C. Do not drop pipe or fittings.
- D. Avoid shock or damage to pipe.
- E. Take measures to prevent damage to exterior surface or internal lining of pipe.
- F. Do not stack pipe higher than recommended by pipe manufacturer.
- G. Store gaskets for mechanical and push-on joints in cool, dry location out of direct sunlight and not in contact with petroleum products.

## PART 2 PRODUCTS

### 2.1 FORCE MAIN

- A. Ductile Iron Pipe: AWWA C151; standard cement mortar lining, AWWA C104, outside coated.
  - 1. Pipe - 3 Inches to 12 Inches: Pressure Class - 350 psi.
- B. Ductile Iron Fittings:
  - 1. AWWA C110; - 350 psi pressure rating.
  - 2. Fitting to be cement mortar lined and outside coated as for ductile iron pipe.
- C. Joints: AWWA C111, where not specifically indicated on Drawings.
  - 1. Type: Mechanical joint or push-on joint.
- D. Rubber Gaskets, Lubricants, Glands, Bolts and Nuts: AWWA C111.

### 2.2 POLYVINYL CHLORIDE (PVC) PIPE

- A. Polyvinyl Chloride (PVC): AWWA C900 DR 18 Class 150 (pipe 4" – 12") and AWWA C905, DR 18 Class 150 (pipe larger than 12").
- B. Polyvinyl Chloride (PVC): ASTM D2241, PVC 1120 (12454-B) or PVC 1220 (12454-C) or PVC 2120 (14333-D); SDR 21 for pipe 2" – 3".
- C. Polyvinyl Chloride (PVC): ASTM D1785, Schedule 80, with fittings conforming to ASTM D2467 for 1-1/2" – 3" pipe inside pump stations and valve vaults.

### 2.3 HIGH DENSITY POLYETHYLENE (HDPE):

- A. ASTM D3035, DR 9, Pressure Rating 250 psi, AWWA C901, PE 4710, Lead-Free, for pipe 1/2" – 3".

### 2.4 UNDERGROUND PIPE MARKERS

- A. Plastic Ribbon Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 2'-6" deep.
- B. Color: BROWN
- C. Text: "CAUTION – SEWER FORCE LINE BURIED BELOW".

## 2.5 BEDDING AND COVER MATERIALS

- A. Bedding: NCDOT #57 or #67 stone.
- B. Cover: This particular Project requires the adoption of specific instructions for excavated soil usage and backfilling:
  - 1. For any trenches with water, sanitary, or storm sewer utilities that are not located under curb or paved areas, backfill using on-site suitable soil when available.
  - 2. For any trenches with water, sanitary, or storm sewer utilities that are located under curb or paved areas, backfill using only approved off-site select borrow.
- C. Soil Backfill from Above Pipe to Finish Grade: This particular Project requires the adoption of specific instructions for excavated soil usage and backfilling:
  - 1. For any trenches with water, sanitary, or storm sewer utilities that are not located under curb or paved areas, backfill using on-site suitable soil when available.
  - 2. For any trenches with water, sanitary, or storm sewer utilities that are located under curb or paved areas, backfill using only approved off-site select borrow.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Verify existing utility water main size, location, and inverts are as indicated on drawings.
- B. Pre-Construction Site Photos: (Recommended Only – NOT required).
  - 1. Take photographs along centerline of proposed pipe trench; minimum one photograph for each 50 feet of pipe trench.
  - 2. Show mail boxes, curbing, lawns, driveways, signs, culverts, and other existing site features.
  - 3. Include project description, date taken and sequential number on back of each photograph.
- C. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs. Use only equipment specifically designed for pipe cutting. The use of chisels or hand saws will not be permitted. Grind edges smooth with beveled end for push-on connections.
- D. Remove scale and dirt on inside and outside before assembly.
- E. Prepare pipe connections to equipment with flanges or unions.

### 3.2 BEDDING

- A. Excavate pipe trench in accordance with Section 31 2317 for Work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated on Drawings.
- B. Dewater excavations to maintain dry conditions and preserve final grades at bottom of excavation.
- C. Provide sheeting and shoring in accordance with Section 31 2317.

### 3.3 INSTALLATION - PIPE

- A. Install pipe in accordance with AWWA C600.
- B. Perform horizontal directional drilling in accordance with Section 33 0524.
- C. Handle and assemble pipe in accordance with manufacturer's instructions and as indicated on drawings.
- D. Steel Rods, Bolt, Lugs, and Brackets: Coat buried steel with one coat of coal tar coating before backfilling.
- E. Lateral Separation of Sewers and Water Mains.
  - 1. Follow NCDEQ for the separation of sanitary sewer and water distribution systems.
  - 2. Parallel Installation
    - a. Normal Conditions - Sewer lines and manholes shall be constructed at least 10 feet horizontally from a waterline whenever possible. The distance shall be measured edge-to-edge.
    - b. Unusual Conditions - When local conditions prevent a horizontal separation of at least 10 feet, then maximum horizontal separation shall be provided with vertical separation of bottom of waterline at least 18 inches above top of sewer. Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA approved water pipe pressure-tested in place to 5 psi without leakage prior to backfilling.
  - 3. Crossing:
    - a. Normal Conditions - Sewers crossing under waterlines shall be laid to provide a separation of at least 18 inches between the bottom of the waterline and the top of the sewer whenever possible.
    - b. Unusual Conditions - When local conditions prevent a vertical separation described in Crossing, Normal Conditions, paragraph above, the following construction shall be used:
      - 1) Sewers passing over or under waterlines shall be constructed of ductile iron pipe with mechanical joints as described in Parallel Installation, Unusual Conditions above.
      - 2) Sewers passing over waterlines shall be laid to provide:

- a) Adequate structural support for the sewers to prevent excessive deflection of the joints and settling on and breaking waterline.
  - b) Maximum separation of water and sewer line joints.
- F. Install ductile iron piping and fittings to AWWA C600.
- G. Weld pipe in accordance with AWWA C206. Weld joints in accordance with AWWA C205.
- H. Flanged Joints: Not to be used in underground installations except within structures.
- I. Route pipe in straight line. Relay pipe that is out of alignment or grade.
- J. Install pipe with no high points. If unforeseen field conditions arise which necessitate high points, install air release valves as directed by Engineer.
- K. Install pipe to have bearing along entire length of pipe. Excavate bell holes to permit proper joint installation. Do not lay pipe in wet or frozen trench.
- L. Prevent foreign material from entering pipe during placement.
- M. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- N. Close pipe openings with watertight plugs during work stoppages.
- O. Establish elevations of buried piping with not less than 36 inches of cover. Measure depth of cover from final surface grade to top of pipe barrel.
- P. Install plastic ribbon tape continuous buried 6 - 12 inches below finish grade.

### 3.4 INSTALLATION - THRUST RESTRAINT

- A. Provide pressure pipeline with restrained joints or concrete thrust blocking at bends, tees, and changes in direction; construct concrete thrust blocking in accordance with Drawings.

### 3.5 FIELD QUALITY CONTROL

- A. Test in accordance with Section 33 3000.

### 3.6 PROTECTION OF FINISHED WORK

- A. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

END OF SANITARY SEWER FORCE MAINS

## **SECTION 334100 - STORM DRAINAGE**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS:**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. North Carolina Department of Transportation Standard Specifications for Roads and Structures, January 2018 Edition.

#### **1.2 SUMMARY:**

- A. This Section includes the roof drainage collection system, the storm sewerage system piping and appurtenances from a point 5 feet outside the building to the point of disposal.

#### **1.3 BASIS OF MEASUREMENT**

- A. Pipe and Fittings:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment: Includes:
    - a. Excavation.
    - b. Removal of unsuitable soil material from site.
    - c. Piping and fittings.
    - d. Bedding as required by these specifications.
    - e. Backfilling.
    - f. Accessories.
    - g. Inspection.
- B. Drainage Structures:
  - 1. Basis of Measurement: Lump Sum.
  - 2. Basis of Payment: Includes:
    - a. Pre-cast structure.
    - b. Excavation.
    - c. Removal of unsuitable soil material.
    - d. Bedding.
    - e. Backfilling.
    - f. Frame and grate.
    - g. Accessories.
    - h. Inspection.

#### 1.4 SUBMITTALS

- A. Product data for pipe, pipe accessories, and structures.
- B. Certification, signed by material producer and contractor, that standard precast and cast in place concrete storm drainage structures comply with NCDOT standards and specifications.
- C. NCDOT approved job mix for bedding stone.
- D. Shop drawings for:
  - 1. Precast or cast-in-place concrete storm drainage structures: manholes, drop inlets, curb inlets, headwalls, etc.
- E. Record drawings of installed storm drainage system.

#### 1.5 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to storm sewerage systems.
- B. Utility Compliance: Comply with state and local regulations and standards pertaining to storm sewerage systems.
- C. All materials shall be new and free of defects (i.e. pipe shall not have chipped spigots or bells).

#### 1.6 PROJECT CONDITIONS

- A. Site Information: Perform site surveys, research public utility records, and verify existing utility locations. Verify that storm sewerage system piping may be installed in compliance with original design and referenced standards.
- B. Locate existing structures and piping to be closed and abandoned.
- C. Existing Utilities: Do not interrupt existing storm sewer serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary storm sewer services.
  - 1. Notify Engineer not less than 48 hours in advance of proposed storm sewer interruptions.
  - 2. Do not proceed with storm sewer interruptions without receiving Engineer's written permission.
- D. Existing utilities across or along the line of work are indicated only in an approximate location. Locate all underground lines and structures. Call "NC one call" at 1-800-632-4949 prior to construction. If utilities are marked that are not shown on the plans, locate utility vertically and horizontally and provide information to Engineer.

## 1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building storm drainage piping.
- B. Coordinate with other utility work.

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. All materials used for construction of the storm sewerage system shall comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.

### 2.2 PIPE AND FITTINGS

- A. Provide pipe and pipe fitting materials compatible with each other. Pipe materials are indicated on the drawings. No substitutions shall be made without written approval from the Engineer.
- B. Reinforced Concrete Pipe (RCP): Shall conform to the requirements of ASTM C76/AASHTO M170, Class III for pipe less than 42" diameter and Class IV for pipe 42" and greater in diameter, unless otherwise indicated.
- C. Reinforced Concrete Pipe – Elliptical: Shall conform to the requirements of ASTM C76, Class III, unless otherwise indicated.
- D. O-Ring Gasket Reinforced Concrete Pipe: Shall conform to the requirements of ASTM C76/AASHTO M170, Class III, unless otherwise indicated. Joints shall conform to the requirements of ASTM C443/AASHTO M198.
- E. Corrugated Polyethylene Pipe (CPP): Shall have a smooth lined interior and meet the requirements of ASTM F405 or AASHTO M252 for 10" diameter and smaller, and ASTM F667 or AASHTO M294 for 12" diameter and larger.
- F. High-Performance Polypropylene Pipe (HPPP): Shall have a smooth lined interior and meet the requirements of ASTM F2764 or AASHTO M330.
- G. PVC Storm Sewer Pipe: Shall conform to the requirements of ASTM D3034, SDR-35 with bell and spigot ends for gasketed joints with ASTM F 477 elastometric seals.
- H. Corrugated Aluminum Alloy Pipe: Meeting the requirements of NCDOT "Standard Specifications for Roads and Structures", 2018 Edition, Section 1032. Aluminized steel pipe is not acceptable.
  - 1. Fittings: Corrugated aluminum alloy.
  - 2. Joints: Corrugated aluminum alloy pipe coupling bands meeting the requirements of AASHTO M196.

## 2.3 MANHOLES

- A. Precast Concrete Manholes: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- B. Cast-in-Place Manholes: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- C. Manhole Steps, Safety Slabs and Inlet Shaping: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- D. Manhole Frames and Covers: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.

## 2.4 DROP INLETS

- A. Precast Concrete Drop Inlets: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- B. Cast-in-Place Drop Inlets: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- C. Drop Inlet Steps, Safety Slabs and Inlet Shaping: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- D. Drop Inlet Frames and Grates: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- E. Plastic Drain Basins: Nyloplast or approved equal.

## 2.5 CATCH BASINS

- A. Precast Concrete Catch Basins: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- B. Cast-in-Place Catch Basins: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.

- C. Catch Basin Steps, Safety Slabs and Inlet Shaping: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.
- D. Catch Basin Frames and Grates: Comply with the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.

## 2.6 CONCRETE AND REINFORCEMENT

- A. Concrete: Conform to the requirements of NCDOT Class A concrete.
- B. Reinforcement: Steel conforming to the following:
  - 1. Fabric: ASTM A 185 welded wire fabric, plain.
  - 2. Reinforcement Bars: ASTM A 615, Grade 60, deformed.
- C. Provide a filter fabric “sock” wrapping for all underdrain pipe.

## 2.7 END WALLS AND END SECTIONS

- A. End walls: Conform to the requirements of the latest edition of the NCDOT Standard Specifications for Roads and Structures.
- B. End sections: Conform to the requirements of the latest edition of the NCDOT Standard Specifications for Roads and Structures. for the size of pipe indicated.

## PART 3- EXECUTION

### 2.8 GENERAL

- A. Install the storm sewerage system in accordance with the latest edition of the NCDOT Standard Specifications for Roads and Structures.

### 2.9 PREPARATION OF FOUNDATION FOR BURIED STORM SEWERAGE SYSTEMS

- A. Grade trench bottom to provide a smooth, firm, stable, and rock-free foundation, throughout the length of the pipe.
- B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid, and backfill with clean sand indicated level.
- C. Install pipe bedding conforming to the requirements of the latest edition of the North Carolina Department of Transportation Standard Specifications for Roads and Structures.

## 2.10 PIPE INSTALLATION

- A. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- B. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited.
- C. Extend storm sewerage system piping to connect to building storm drains, of sizes and in locations indicated.
- D. Join and install concrete pipe and fittings per NCDOT specifications.
- E. Join and install PE pipe and fittings per manufacturer's recommendations.
- F. Join different types of pipe with standard manufactured couplings and fittings intended for that purpose.

## 2.11 MANHOLES

- A. General: Install manholes complete with accessories as indicated. Form continuous concrete or split pipe section channel and benches between inlets and outlet. Set tops of frames and covers flush with finish grade, unless otherwise indicated.
- B. Place precast concrete manhole sections as indicated and install in accordance with ASTM C 891.
- C. Construct cast-in-place manholes as indicated.
- D. Apply bituminous mastic coating at joints of sections.

## 2.12 CLEANOUTS

- A. Install cleanouts and extension from sewer pipe to cleanout at grade as indicated. Set cleanout frame and cover in concrete block 12 by 12 by 6 inches deep, except where location is in concrete paving. Set top of cleanout flush with finish grade.

## 2.13 DROP INLETS AND CURB INLETS

- A. Construct drop inlets and curb inlets to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

## 2.14 INLET SHAPING

- A. Construct inlet shaping conforming to NCDOT Standards at all drop inlets, curb inlets and manholes.

## 2.15 FIELD QUALITY CONTROL

- A. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
  - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
  - 2. Place plugs in ends of uncompleted pipe at end of day or whenever work stops.
  - 3. Flush piping between manholes and drop inlets to remove collected debris. Flush pipes through an approved erosion and sediment control measure.
- B. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.
  - 1. Make inspections after pipe between manholes and manhole locations has 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.

END OF STORM DRAINAGE