SPECIFICATIONS

PERMIT SET
VOLUME 3 of 4
Divisions 23 - 28

for

The City of Key West
City Hall
at Glynn Archer School

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Submitted by:

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SECTION 230500

COMMON WORK RESULTS 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. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
6. Grout.
7. HVAC demolition.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.

2. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.

2. Mechanical sleeve seals.

3. Escutcheons.

B. Welding certificates.

C. LEED Submittals:

1. General:

a. Collect and submit data as required for completing the applicable LEED Submittal Template(s).

2. Product Data for Credit EQ 4.1: Submit documentation required to show credit compliance in the LEED Submittal Template, including but not limited to manufacturer's name, product name, specific VOC data, and the corresponding allowable VOC from the referenced standard, for each CPVC and PVC solvent cement; and any other sealant or adhesive specified under this section.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Panels."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493. Max VOC content = 490-g/L; Zero VOC preferred.

2. PVC Piping: ASTM D 2564. Max VOC content = 510g/l; Zero VOC preferred. Include primer according to ASTM F 656.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

1. Manufacturers:

a. Epco Sales, Inc.

b. Watts Industries, Inc.; Water Products Div.

c. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.

b. Epco Sales, Inc.

c. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Calpico, Inc.

b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Perfection Corp.

b. Precision Plumbing Products, Inc.

c. Sioux Chief Manufacturing Co., Inc.

d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Stainless steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.7 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

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

3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Section "024100 Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

b. Insulated Piping: One-piece, stamped-steel type with spring clips.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

2. Existing Piping: Use the following:

a. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.

b. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.

M. Sleeves are not required for core-drilled holes.

N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.

b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealers" for materials and installation.

O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 078400 “Firestopping for materials”; see also Section 235017 “Sleeves and Seals for HVAC Piping”.

R. Verify final equipment locations for roughing-in.

S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. 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. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

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 the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's 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.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 3000-psi , 28-day compressive-strength concrete and reinforcement as specified in Section 03300 "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

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

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

3.9 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 230500

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 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.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 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. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. 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:

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.

2.5 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: 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 230513

SECTION 230516

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rubber union connector packless expansion joints.
   2. Alignment guides and anchors.
   3. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. LEED Submittals:
   1. General:
      a. Collect and submit data as required for completing the applicable LEED Submittal Template(s).
   2. Product Data for Credit EQ 4.1; Submit documentation required to show credit compliance in the LEED Submittal Template, including but not limited to manufacturer’s name, product name, specific VOC data, and the corresponding allowable VOC from the referenced standard, for epoxy resin to be used as part of the anchoring system, and any other sealant or adhesive specified under this section.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

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

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints:
   1. Material: Twin reinforced-rubber spheres with external restraining cables.
   2. Minimum Pressure Rating: 150 psig at 170 deg F, unless otherwise indicated.
   3. End Connections for NPS 2 and Smaller: Threaded.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

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

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed. Max. VOC content = 70g/L.
    b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230517

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:
1. General:
   a. Collect and submit data as required for completing the applicable LEED Submittal Template(s).
2. Product Data for Credit EQ 4.1; Submit documentation required to show credit compliance in the LEED Submittal Template, including but not limited to manufacturer's name, product name, specific VOC data, and the corresponding allowable VOC from the referenced standard, for cementations grouts, and any other adhesive or sealant specified under this section.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

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

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout. Max VOC content = 65g/L.

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. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

2. Using grout, seal 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 079005 "Joint Sealers."

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 078400 "Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 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. Exterior Concrete Walls below Grade:

   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.

END OF SECTION 230517

SECTION 230518

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish with setscrew, spring or other device to hold them securely in place.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

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

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

SECTION 230519

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Pitot-tube flowmeters.
7. Venturi flowmeters.

1.2 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 Manufacturers: Ashcroft Inc, Trerice H.O. Co., Weksler, Weiss Instruments.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.

D. Connector Type(s): Union joint, adjustable angle rigid, back and rigid, bottom, with unified-inch screw threads.

E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

G. Window: Plain glass.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.

   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Plastic; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass.

7. Stem: Aluminum, brass, or stainless steel and of length to suit installation.

   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.5 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.
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.

2.6 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   1. Standard: ASME B40.100.
   2. Case: Liquid-filled Sealed; brass; 4-1/2-inch nominal diameter.
   3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   4. 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.
   5. Movement: Mechanical, with link to pressure element and connection to pointer.
   6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.

7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Brass.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Liquid-filled Sealed type; brass; 4-1/2-inch nominal diameter with front flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. 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.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Brass.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.7 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.8 FLOWMETERS

A. Pitot-Tube Flowmeters:
1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Insertion type; for inserting probe into piping and measuring flow directly in gallons per minute.

B. Venturi Flowmeters:
1. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.

4. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

    a. Scale: Gallons per minute.
    b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids.

K. Install flow indicators in piping systems in accessible positions for easy viewing.

L. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

M. Install flowmeter elements in accessible positions in piping systems.

N. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

O. Install permanent indicators on walls or brackets in accessible and readable positions.

P. Install connection fittings in accessible locations for attachment to portable indicators.

Q. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

3.2 THERMOMETER SCALE-RANGE SCHEDULE

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

B. Scale Range for Air Ducts: 0 to 100 deg F.

3.3 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:

1. Liquid-filled Sealed, direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be the following:

1. Liquid-filled Sealed, direct-mounted, metal case.

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

1. Liquid-filled Sealed, direct-mounted, metal case.

3.4 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 300 psi.

3.5 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Pitot-tube or Venturi type.

B. Thermal-Energy Meters: Impeller-turbine type.

END OF SECTION 230519

SECTION 230523.11

GLOBE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

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

C. Refer to HVAC valve schedule articles for applications of valves.

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

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

F. Valves in Insulated Piping: With 2-inch stem extensions.

2.2 BRONZE GLOBE VALVES

A. Class 125 Bronze Globe Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 150 Bronze Globe Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 300 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GLOBE VALVES

A. Class 125 Iron Globe Valves:
   1. Description:

      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.
      g. Operator: Handwheel or chainwheel.

B. Class 250 Iron Globe Valves:
   1. Description:

      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 500 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.

f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

2.4 CHAINWHEELS

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

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

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

3.2 ADJUSTING

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Throttling Service except Steam: Globe valves.
2. Throttling Service, Steam: Globe valves.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze globe valves, Class 125, bronze disc, with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 with flanged ends.

END OF SECTION 230523.11

SECTION 230523.12

BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

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

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

D. Refer to HVAC valve schedule articles for applications of valves.

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

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

G. Valve Actuator Types:
   1. Handlever: For quarter-turn valves smaller than 2”.

H. Valves in Insulated Piping:

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

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

2.2 BRONZE BALL VALVES

A. One-Piece Bronze Ball Valves with Bronze Trim:
   1. Description:

      a. Standard: MSS SP-110.
      b. CWP Rating: 400 psig.
      c. Body Design: One piece.
      d. Body Material: Bronze.
      e. Ends: Threaded.
      f. Seats: PTFE.
      g. Stem: Bronze.
      h. Ball: Chrome-plated brass.
      i. Port: Reduced.

B. One-Piece Bronze Ball Valves with Stainless-Steel Trim:
   1. Description:

      a. Standard: MSS SP-110.
      b. CWP Rating: 600 psig.
      c. Body Design: One piece.
      d. Body Material: Bronze.
      e. Ends: Threaded.
      f. Seats: PTFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel, vented.
      i. Port: Reduced.

C. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:
   1. Description:

      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.
      c. CWP Rating: 600 psig.

d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:
1. Description:

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

E. Two-Piece Bronze Ball Valves with Regular Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Two-Piece Bronze Ball Valves with Regular Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.

i. Ball: Stainless steel, vented.
j. Port: Regular.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3.3 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: One piece, full port, bronze with bronze trim.

1. Valves may be provided with solder-joint ends instead of threaded ends.

END OF SECTION 230523.12

SECTION 230523.13

BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. High-performance butterfly valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B31.1 for power piping valves.
4. ASME B31.9 for building services piping valves.

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

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

E. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.

3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

F. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

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

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
1. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated or -coated ductile iron.

C. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:
1. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

2.3 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

1. Description:

    a. Standard: MSS SP-68.
    b. CWP Rating: 285 psig at 100 deg F.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
    e. Seat: Reinforced PTFE or metal.
    f. Stem: Stainless steel; offset from seat plane.
    g. Disc: Carbon steel.
    h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
    1. Description:

    a. Standard: MSS SP-68.
    b. CWP Rating: 720 psig at 100 deg F.
    c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
    d. Body Material: Carbon steel, cast iron, or ductile iron.
    e. Seat: Reinforced PTFE or metal.
    f. Stem: Stainless steel; offset from seat plane.
    g. Disc: Carbon steel.
    h. Service: Bidirectional.

2.4 CHAINWHEELS

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

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

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

3.2 ADJUSTING

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

3.3 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 6 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze or stainless-steel disc.
2. High-Performance Butterfly Valves: Class 150, single flange.

END OF SECTION 230523.13

SECTION 230523.14

CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

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

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

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

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

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

2.2 BRONZE SWING CHECK VALVES

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

      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
   1. Description:

      a. Standard: MSS SP-80, Type 4.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: PTFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:
   1. Description:

      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 300 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
   1. Description:

      a. Standard: MSS SP-80, Type 4.
      b. CWP Rating: 300 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.
      f. Disc: PTFE.

2.3 IRON SWING CHECK VALVES

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

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Composition.
      h. Seat Ring: Bronze.
      i. Disc Holder: Bronze.
      j. Disc: PTFE.
      k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
      c. NPS 14 to NPS 24, CWP Rating: 300 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   1. Description:

      a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and weight.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

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

3.2 ADJUSTING

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring; resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves: Class 125, metal seats.
3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and weight.

END OF SECTION 230523.14

SECTION 230523.15

GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

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

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

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

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

F. RS Valves in Insulated Piping: With 2-inch stem extensions.

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

2.2 BRONZE GATE VALVES

A. Class 125, NRS, Bronze Gate Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

B. Class 125, RS, Bronze Gate Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

C. Class 150, NRS, Bronze Gate Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

D. Class 150, RS, Bronze Gate Valves:
   1. Description:

      a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:
1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

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

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

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

3.2 ADJUSTING

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

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze Valves, Class 125, NRS with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron Gate Valves, Class 125, NRS.

END OF SECTION 230523.15

SECTION 230523.16

PLUG VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lubricated plug valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

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

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

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

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

F. Valve Actuator Types: Wrench. Furnish Owner with one wrench for every five plug valves, for each size square plug-valve head.

2.2 LUBRICATED PLUG VALVES

A. Class 125, Lubricated Plug Valves with Threaded Ends:
   1. Description:

      a. Standard: MSS SP-78, Type I single gland.
      b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
      c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      d. Pattern: Regular.
      e. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Lubricated Plug Valves with Flanged Ends:
   1. Description:

      a. Standard: MSS SP-78, Type I single gland or Type II regular gland.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      e. Pattern: Regular.
      f. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
   1. Description:

      a. Standard: MSS SP-78, Type IV.
      b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
      c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      d. Pattern: Regular.
      e. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
   1. Description:

      a. Standard: MSS SP-78, Type IV.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      d. Pattern: Regular.
      e. Plug: Cast iron or bronze with sealant groove.

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.

E. Install chainwheels on operators for plug valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

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: Plug valves.

B. If valves with CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Lubricated Plug Valves: Class 125, regular gland, flanged.

END OF SECTION 230523.16

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes 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.

1.3 ACTION SUBMITTALS

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

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

C. LEED Submittals:

1.General:

a. Collect and submit data as required for completing the applicable LEED Submittal Template(s).

2. Product Data for Credit EQ 4.1: Submit documentation required to show credit compliance in the LEED Submittal Template, including but not limited to

manufacturer's name, product name, specific VOC data, and the corresponding allowable VOC from the referenced standard for cementations grouts, and any other adhesive or sealant specified under this section.

D.

1. Trapeze pipe hangers.
2. Equipment supports.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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 galvanized steel.

B. Copper Pipe 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 stainless steel galvanized steel.

2.2 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. System must be approved by structural engineer and owner.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- 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.

2.3 EQUIPMENT SUPPORTS

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

2.4 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. Max. VOC content= 65g/L.

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. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. 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.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. 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.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. 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.

L. 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 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 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: 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.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 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 must comply with LEED VOC restrictions as specified in Section 099000 "Painting and Coating" and Section 099610 "High Performance Coatings for Steel."

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 metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment 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 noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

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.
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.

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 up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. 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.

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. 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.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230548.13

VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Open-spring isolators.
3. Pipe-riser resilient supports.
4. Elastomeric hangers.
5. Spring hangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators.

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.
4. Surface Pattern: Ribbed pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.3 PIPE-RISER RESILIENT SUPPORT

A. Provide 1” neoprene pad under floor pipe clamp. Provide ¼” metal plate under and on top fo neoprene pad.

2.4 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.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 230548.13

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
1. General:
   a. Collect and submit data as required for completing the applicable LEED Submittal Template(s).
2. Product Data for Credit EQ 4.1: Submit documentation required to show credit compliance in the LEED Submittal Template, including but not limited to manufacturer's name, product name, specific VOC data, and the corresponding allowable VOC from the referenced standard for all types of adhesives or sealants specified under this section.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. 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.
4. Fasteners: Stainless-steel rivets or self-tapping screws.

5. 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. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
4. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances 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.
5. Fasteners: Stainless-steel rivets or self-tapping screws.
6. 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 WARNING SIGNS AND 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: Black.

C. Background Color: White.

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. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full 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. Max. VOC content = 80g/L.

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.

2.4 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: Black.

C. Background Color: White.

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. Max. VOC content = 80g/L.

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 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 099000 "Painting and Coating".

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. 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.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping: Black letters on a safety-orange background.
2. Refrigerant Piping: White letters on a safety-gray background.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Green: For exhaust-, outside-, relief-, return-, and mixed-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 230553

SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

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

F. TDH: Total dynamic head.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC, NEBB, or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC, NEBB or TABB 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."

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 strategies and step-by-step procedures for balancing the systems.

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. Duct systems are complete with terminals installed.
   b. Volume, smoke, and fire dampers are open and functional.
   c. Clean filters are installed.
   d. Fans are operating, free of vibration, and rotating in correct direction.
   e. Variable-frequency controllers' startup is complete and safeties are verified.
   f. Automatic temperature-control systems are operational.
   g. Ceilings are installed.
   h. Windows and doors are installed.
   i. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning per the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete and safeties are verified.
   k. 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 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "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 233113 "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 commissioning authority 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.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
    g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. 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 any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
   d. Mark final settings.
   e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
   f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
   b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
   c. Convert pressure to head and correct for differences in gage heights.
   d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
   e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.

7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

10. Verify that memory stops have been set.

3.10 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.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

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

3.11 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. 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. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. 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.

F. Apparatus-Coil Test Reports:

1. Coil Data:

   a. System identification.
   b. Location.

c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. E.lectric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.

c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

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.
g. Number, make, and size of belts.

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. Suction static pressure in inches wg.

I. Round, Flat-Oval, 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.

J. 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.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.

e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

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

1. Unit Data:

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

2. Test Data (Indicated and Actual Values):

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

M. Instrument Calibration Reports:

1. Report Data:

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

3.12 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.

B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.13 ADDITIONAL TESTS

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

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at 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.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. 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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm 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. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 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.

2.5 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.
5. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. ASJ Flashing Sealants, and Vinyl 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. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing.
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   4. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   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.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.

5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Aluminum Bands: 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. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Aluminum or Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Max. VOC content = 80g/L. Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. 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: Max. VOC content = 70 g/L. Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Stainless steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-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.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.11 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.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-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.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches 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 078400 "Firestopping" for firestopping and fire-resistive joint sealers and Section 230517 “Sleeves and Sleeves Seals for HVAC Piping”.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078400 "Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches 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 overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches 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.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches 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, space 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 overcompress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches 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. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-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.

3.5 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

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

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078400 "Firestopping."

3.7 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with low or Zero VOC content paint system identified below and as specified in Section 099000 "Painting and Coating".

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. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

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

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.10 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. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

END OF SECTION 230713

SECTION 230716

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Chilled-water pumps.
   2. Expansion/compression tanks.
   3. Air separators.

B. Related Sections:

   1. Section 230713 "Duct Insulation."
   2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

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

   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail removable insulation at equipment connections.
   4. Detail application of field-applied jackets.
   5. Detail application at linkages of control devices.
   6. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Block Insulation: ASTM C 552, Type I.
   2. Special-Shaped Insulation: ASTM C 552, Type III.
   3. Board Insulation: ASTM C 552, Type IV.
   4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

I. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.

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

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 MASTICS

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

   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm 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. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 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. Joint Sealants:

   1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide one of the following:

      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
      b. Eagle Bridges - Marathon Industries; 405.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
      d. Mon-Eco Industries, Inc.; 44-05.
      e. Pittsburgh Corning Corporation; Pittseal 444.

   2. Joint Sealants for Polystyrene Products: Subject to compliance with requirements, provide one of the following:

      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
      b. Eagle Bridges - Marathon Industries; 405.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.

d. Mon-Eco Industries, Inc.; 44-05.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated tank heads and tank side panels.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing.
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   4. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   5. Factory-Fabricated Fitting Covers:

      a. Same material, finish, and thickness as jacket.
      b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      c. Tee covers.
      d. Flange and union covers.
      e. End caps.
      f. Beveled collars.
      g. Valve covers.
      h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

F. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

G. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   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.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

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

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches.
2. Film Thickness: 4 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches.
2. Film Thickness: 6 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

2.9 SECUREMENTS

A. Aluminum Bands: 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. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Aluminum, 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.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, nylon sheet, 0.030 inch 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.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Aluminum, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum 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.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.10 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.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

   1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch-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.

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.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
d. Do not overcompress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-

diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from aluminum, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.4 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

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

D. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.5 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099000 " Painting and Coating"

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.

D. Do not field paint aluminum or stainless-steel jackets.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Chilled-water pump insulation shall be the following:

1. Cellular Glass: 3 inches thick.

D. Chilled-water expansion/compression tank insulation shall be the following:

1. Cellular Glass: 1-1/2 inches thick.

E. Dual-service heating and cooling expansion/compression tank insulation shall be the following:

1. Cellular Glass: 1-1/2 inches thick.

F. Chilled-water air-separator insulation shall be the following:

1. Cellular Glass: 2 inches thick.

3.8 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
1. Aluminum, Smooth: 0.016 inch thick.

3.9 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Smooth with Z-Shaped Locking Seam: 0.016 inch thick.

END OF SECTION 230716

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Chilled-water piping, indoors and outdoors.
2. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Block Insulation: ASTM C 552, Type I.
   2. Special-Shaped Insulation: ASTM C 552, Type III.
   3. Board Insulation: ASTM C 552, Type IV.
   4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
   6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

G. Mineral-Fiber, Preformed Pipe Insulation:

H. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm 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. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 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.

2.5 SEALANTS

A. Joint Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing.
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   4. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   5. Factory-Fabricated Fitting Covers:

      a. Same material, finish, and thickness as jacket.
      b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      c. Tee covers.
      d. Flange and union covers.
      e. End caps.
      f. Beveled collars.
      g. Valve covers.
      h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

F. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

G. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   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.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Width: 3 inches.
   2. Film Thickness: 4 mils.
   3. Adhesive Thickness: 1.5 mils.
   4. Elongation at Break: 145 percent.
   5. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Width: 3 inches.
   2. Film Thickness: 6 mils.
   3. Adhesive Thickness: 1.5 mils.
   4. Elongation at Break: 145 percent.
   5. Tensile Strength: 55 lbf/inch in width.

2.10 SECUREMENTS

A. Aluminum Bands: 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: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of 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. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078400 "Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078400 "Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, 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 where access for service is required. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as 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.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe 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. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as 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 PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches 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 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where 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.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

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

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

D. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.

3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099000 "Painting and Coating".

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.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water, above 40 Deg F: Insulation shall be one of the following:

1. Cellular Glass: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping: Flexible elastomeric, 1 inch thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing: Flexible elastomeric, 1 inch thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water: Insulation shall be the following:

1. Cellular Glass: 3 inches thick.

B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be the following:
1. Flexible Elastomeric: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be the following:

1. Flexible Elastomeric: 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. None.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC: 30 mils thick.

END OF SECTION 230719

SECTION 230800

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for the following HVAC&R systems, assemblies, and equipment:

1. Energy supply systems, including solar-energy supply.
2. Cooling generation systems, including chilled-water systems and direct-expansion systems.
3. Distribution systems, chilled-water distribution systems, exhaust systems and air-handling units.
4. Terminal and packaged units, including unit ventilators unit heaters fan-coil units, electric heating, packaged units.
5. Vibration and sound systems, including sound attenuation, vibration isolation devices.
6. Controls and instrumentation, including BAS, energy monitoring and control system.
7. Systems testing and balancing verification, including chilled-water piping systems, supply-air systems, return-air systems, exhaust-air systems.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. DDC: Direct digital controls.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

E. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For BAS and HVAC&R Testing Technician.

B. Construction Checklists: For the following:

1. Vibration controls for HVAC&R piping and equipment.
2. Instrumentation and control for HVAC&R.
3. Cooling-water piping and accessories.
4. Refrigerant piping.
5. Metal ducts and accessories.
6. Fans.
7. Particulate air filtration.
8. Air-handling units.
9. Computer-room air conditioners.
10. Chillers.
11. Pumps.

1.4 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level with knowledge of BAS, HVAC&R, electrical concepts, and building operations.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. International Society of Automation (ISA) Certified Control Systems Technician (CCST) Level I.

B. HVAC&R Testing Technician Qualifications: Technicians to perform HVAC&R construction checklist verification tests, construction checklist verification test demonstrations, commissioning tests, and commissioning test demonstrations shall have the following minimum qualifications:

1. Journey-level or equivalent skill level. Vocational School four-year program graduate or an Associates degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC&R systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC&R equipment, assemblies, and systems.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
3. One of the following:

a. National Environmental Balancing Bureau (NEBB) Certified Testing, Adjusting, and Balancing Technician.
b. Associated Air Balance Council (AABC) Certified Test and Balance Technician.
c. Owner retains the right to waive NEBB or AABC Certification.

C. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform HVAC&R commissioning work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:

a. Equipment/instrument identification number.
b. Planned commissioning application or use.
c. Manufacturer, make, model, and serial number.
d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.

2. Test equipment and instrumentation shall meet the following criteria:

a. Capable of testing and measuring performance within the specified acceptance criteria.
b. Be calibrated at the manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
c. Be maintained in good repair and operating condition throughout the duration of use on this Project.
d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the commissioning process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:

a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:

1) Instrument or tool identification number.
2) Equipment schedule designation of equipment for which the instrument or tool is required.
3) Manufacturer, make, model, and serial number.
4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

b. Include a separate list of proprietary test instrumentation and tools in the operation and maintenance manuals.
c. HVAC&R proprietary test instrumentation and tools become the property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Construction Checklists: Prepare and submit detailed construction checklists for HVAC&R systems, subsystems, equipment, and components.

1. Contributors to the development of construction checklists shall include, but are not limited to, the following:

a. HVAC&R systems and equipment installers.
b. TAB technicians.
c. HVAC&R instrumentation and controls installers.

F. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.

2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.
3. Commissioning test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

G. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

H. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

I. Coordinate schedule with, and perform the following activities at the direction of, Commissioning Coordinator.

J. Comply with construction checklist requirements, including material verification, installation checks, start-up, and performance tests requirements specified in Sections specifying HVAC systems and equipment.

K. Provide technicians, instrumentation, tools, and equipment to complete and document the following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Commissioning tests.
4. Commissioning test demonstrations.

3.2 TAB COMMISSIONING TESTS

A. TAB Verification:

1. Conditions of the Test:

a. Commissioning Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
b. Systems operating in full heating mode with minimum outside-air volume.
c. Systems operating in full cooling mode with minimum outside-air volume].
d. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

2. Acceptance Criteria:

a. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

b. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
c. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.3 CENTRAL REFRIGERATION SYSTEM COMMISSIONING TESTS

A. Start and Stop Chilled-Water Pump(s):

1. Prerequisites: Installation verification of the following:

a. Startup of chilled-water pump(s).
b. Input Device: Flow switch in condenser-water circuit.
c. Output Device: DDC system command to starter relay.
d. Display of the following at the operator's workstation:

1) Chilled-water flow indication.
2) Chilled-water pump(s) on-off status.
3) Chilled-water pump(s) on-off indication.

2. Conditions of the Test:

a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device to the "disable" state.

3. Acceptance Criteria:

a. Start: Chilled-water pump(s) start when and only when the enable-input device is in the "enable" state.
b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

B. Alternative Chiller(s):

1. Prerequisites: Installation verification of the following:

a. Input Device: DDC system software.
b. Output Device: DDC system command to chiller terminal strip.
c. Display:

1) Chiller(s) on-off indication.

2) Chiller failure alarm.

2. Conditions of the Test:
   a. Add/Drop Sequence - Increasing Demand: Increase chilled-water demand incrementally to observe the corresponding addition of chillers. Increase demand gradually as the load approached the set point for adding the next chiller to permit observation of the actual load at the time the next chiller is enabled.
   b. Add/Drop Sequence - Decreasing Demand: Decrease chilled-water demand incrementally to observe the corresponding dropping of chillers. Decrease demand gradually as the load approached the set point for dropping the next chiller to permit observation of the actual load at the time the next chiller is disabled.
   c. Add/Drop Sequence - Operating Chiller Fail:
   d. Add/Drop Sequence - Chiller Start Fail:

3. Acceptance Criteria:
   a. Add/Drop Sequence - Increasing Demand: Chillers are added at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus 2.0 deg F of set point.
   b. Add/Drop Sequence - Decreasing Demand: Chillers are dropped at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus 2.0 deg F of set point.
   c. Add/Drop Sequence - Operating Chiller Fail: When an operating chiller fails, the next chiller in sequence starts and a chiller failure alarm is initiated for the failed chiller.
   d. Add/Drop Sequence - Chiller Start Fail: When a chiller fails to start, the next chiller in sequence starts in its place, and a chiller failure alarm is initiated for the failed chiller.

3.4 TERMINAL UNIT EQUIPMENT COMMISSIONING TESTS

A. Variable-Air-Volume Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following:

   a. Occupancy Input Device: Occupancy sensor.
   b. Occupancy Output Device: DDC system binary output.
   c. Room Temperature Input Device: Room thermostat.
   d. Room Temperature Output Device: Electronic damper actuators and control-valve operators.
   e. Display the following at the operator's workstation:

      1) Room/area served.
      2) Room occupied/unoccupied.
      3) Room temperature indication.
      4) Room temperature set point.

5) Room temperature set point, occupied.
6) Room temperature set point, unoccupied.
7) Air-damper position as percentage open.
8) Control-valve position as percentage open.

2. Conditions of the Test:

a. Commissioning Test Demonstration Sampling Rate: 10 percent of each model/size unit.
b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point plus or minus 1.0 deg F.
c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point plus or minus 1.0 deg F.

3. Acceptance Criteria:

a. Temperature Control - Occupied:

1) Control system status changes from "occupied" to "unoccupied" after the specified time.
2) Room temperature is stable at occupied set point plus or minus 1.0 deg F within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F during transition.

b. Temperature Control - Unoccupied:

1) Control system status changes from "unoccupied" to "occupied" immediately.
2) Room temperature is stable at unoccupied set point plus or minus 1.0 deg F within 30 minutes of occupancy.

3.5 AIR-HANDLING SYSTEM COMMISSIONING TESTS

A. Supply Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:
a. Volume Control Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to conditioned-space static pressure.
b. Volume Control Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
c. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.

d. High-Pressure Output Device: DDC system binary output to alarm panel and motor starter.
e. Display the following at the operator's workstation:

1) Supply-fan-discharge static-pressure indication.
2) Supply-fan-discharge static-pressure set point.
3) Supply-fan airflow rate.
4) Supply-fan speed.

2. Conditions of the Test:

a. Minimum supply-air flow.
b. Midrange Supply-Air Flow: 50 to 60 percent of maximum.
c. Maximum supply-air flow.
d. Excess supply-air discharge static pressure.

3. Acceptance Criteria:

a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
b. Fan stops and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure plus or minus 2 percent.

B. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:

a. Minimum Position Input Device: DDC system time schedule.
b. Output Device: DDC system analog output to modulating damper actuator(s).
c. Supply-Air Temperature Input Device: Electronic temperature sensor.
d. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.
e. Display the following at the operator's workstation:

1) Mixed-air-temperature indication.
2) Mixed-air-temperature set point.
3) Mixed-air damper position.

2. Conditions of the Test:

a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
c. Supply-Air Temperature Control: Override supply-air temperature set point to a value 2.0 deg F above current supply-air temperature.

d. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature.
e. Unoccupied Time Control: Advance to unoccupied schedule time.
f. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at hourly intervals. Submit trend data for 24-hour periods in which natural conditions require heating reset control, supply-air temperature control, and cooling reset control.

    1) Minimum position input device.
    2) Heating reset input device.
    3) Supply-air temperature input device.
    4) Cooling reset input device.

3. Acceptance Criteria:

    a. Occupied Time Control: Mixed-air control is active in occupied mode.
    b. Minimum Damper Position Control: Controller positions outdoor-air dampers to minimum position.
    c. Supply-Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary supply-air temperature set point plus or minus 1.0 deg F.
    d. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature.
    e. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
    f. Control Data Trend Log: Data verifies control according to sequence of control.

END OF SECTION 230800

SECTION 230923

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

1. PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.

B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades.

C. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

D. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.2 BMS DESCRIPTION

A. The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.

(Optional) The BMS shall utilize wireless sensor- and field-level communication as described in the following sections. Contractor shall be responsible for coordination with the owner's IT staff to ensure there will be no interference with other wireless communication taking place in the building (e.g. WiFi).

B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.

C. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specifications together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.

D. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

E. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

1. Operator information, alarm management and control functions.
2. Enterprise-level information and control access.
3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
4. Diagnostic monitoring and reporting of BMS functions.
5. Offsite monitoring and management access.
6. Energy management
7. Standard applications for terminal HVAC systems.
8. Indoor Air Quality monitoring and control

1.3 QUALITY ASSURANCE

A. General

1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
2. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
3. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
4. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

1.4 REFERENCES

A. In the case of conflicts or discrepancies, the more stringent regulation shall apply.

1.5 SUBMITTALS

A. Shop Drawings, Product Data, and Samples

1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
2. The BMS Contractor shall correct any errors or omissions noted in the first review.
3. At a minimum, submit the following:

a. BMS network architecture diagrams including all nodes and interconnections.
b. Systems schematics, sequences and flow diagrams.
c. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
d. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
e. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
f. Details of all BMS interfaces and connections to the work of other trades.
g. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.6 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:
   a. Table of contents.
   b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
   c. Manufacturers product data sheets or catalog pages for all products including software.
   d. System Operator’s manuals.
   e. Archive copy of all site-specific databases and sequences.
   f. BMS network diagrams.
   g. Interfaces to all third-party products and work by other trades.

1.7 WARRANTY

A. Standard Material and Labor Warranty:

1. Provide a one-year labor and material warranty on the BMS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation,

workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

3. Maintain an adequate supply of materials within 300 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

2. PART 2 – PRODUCTS

2.1 GENERAL DESCRIPTION

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall not be limited to a single open communication protocol standard, but to also integrate a wide variety of third-party devices and applications via additional protocols and through the latest software standards. 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 Management System shall consist of the following:

1. Standalone Network Automation Engine(s)
2. DDC Controllers (HVAC etc.)
3. Local Display Devices
4. Operator Workstation

C. Acceptable Manufacturers

1) Johnson Controls, Metasys (Basis of Bid)
2) Siemens Building Systems, APOGEE
3) Trane, Summit

2.2 BMS ARCHITECTURE

A. Automation Network

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
2. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

B. Control Network

1. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
2. DDC Controllers shall reside on the control network.
3. (Optional) The control network shall utilize ZigBee wireless mesh protocol for sensor- and field-level communication. The wireless network shall be capable of being integrated with any existing or future wired network with no loss of BMS integrity.

2.3 USER INTERFACE

A. Dedicated Web Based User Interface

1. The Owner shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines 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 BMS 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. Microsoft Internet Explorer for user interface functions
   b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
   c. Microsoft Outlook or other eMail program 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 – The personal computer(s) shall be configured as follows:
   a. Memory – 512 MB (Minimum)
   b. CPU– Pentium 4 or greater; 2.8 MHz or Faster Clock Speed
   c. Hard Drive – 40 GB or greater hard drive
   d. Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department
   e. CD ROM Drive – 32X performance
   f. Ports – (2) Serial and (1) parallel, (2) USB ports
   g. Keyboard – 101 Keyboard and 2 Button Mouse
   h. CRT configuration – 1-2 CRTs as follows:

◊ Each Display – 17” Flat Panel Monitor 1280 x 1024 resolution minimum

◊ Display card with multiple monitor support

i. LAN communications – Ethernet communications board; 3Comm or equal.

4. Operating System Software

a. Windows XP

b. Where user interface is not provided via browser, provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.

B. Distributed Web Based User Interface

1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.

2. The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser.

C. User Interface Application Components

1. Operator Interface

a. An integrated browser based client application shall be used as the user operator interface program.

b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

c. The user interface software shall provide help menus and instructions for each operation and/or application.

d. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Schedules

a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

◊ Weekly schedules

◊ Exception Schedules

◊ Monthly calendars.

b. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.

3. Password

a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, Based on an assigned password.

4. Dynamic Color Graphics

a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.

b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.

The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

c. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows

5. Historical trending and data collection

a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

◊ Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:

Defined time interval

Upon a change of value

6. Trend data viewing and analysis

a. Provide a trend viewing utility that shall have access to all database points.

b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.

c. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

2.4 AUTOMATION ENGINES

A. Network Automation Engine (NAE)

1. The Network Automation Engine shall be a fully user-programmable, supervisory controller. The Automation Engine shall monitor the network of distributed application-specific controllers, provide global strategy and

direction, and communicate on a peer-to-peer basis with other Automation Engines.

2. Automation network – The Network Automation Engine (NAE) shall reside on the automation network.

3. User Interface – Each NAE shall have the ability to deliver a web based user interface as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI. Systems without such capability at this level shall provide a user interface via the combination of operator workstations and Web servers as determined by the owner for comparable operation.

4. Power Failure – In the event of the loss of normal power, The NAE 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. Flash memory shall be incorporated for all critical controller configuration data.

   a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions.

   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.

5. Certification – All controllers shall be listed by Underwriters Laboratories (UL).

2.5 APPLICATION SPECIFIC CONTROLLERS

A. Air Handling Unit Controllers (AHU)

1. Each Air Handling Unit controller shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each AHU controller shall be a microprocessor-Based, multi-tasking, real-time digital control processor

B. VAV Modular Assembly (VMA)

1. The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units.

2. The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.

2.6 SOFTWARE PROGRAMMING/TOOLS

A. Program Editor

1. Definition of operator device characteristics, DDC panels, individual points, applications, and control sequences shall be performed through the browser based user interface.
2. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
3. The programming environment shall provide help menus and instructions for each operation and/or application performed, for all programming library functions, and for the programming language itself.

2.7 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:

Point Type	**Accuracy**
Chilled Water	± .5°F.
Room Temp	± .5°F.
Duct Temperature	± .5°F.
All Others	± .75°F.

2. Room Temperature and Room Temperature/Humidity Sensors
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. Room sensors shall have the following options when specified:
      ◊ Setpoint reset slide switch providing a ±3 degree (adjustable) range.
      ◊ Individual heating/cooling setpoint slide switches.
      ◊ A momentary override request push button for activation of after-hours operation.
      ◊ Analog thermometer.

c. (Optional) Room sensors shall capable of communicating wirelessly via the ZigBee protocol. Sensors shall utilize two (2) AA batteries and shall not require a dedicated 24 VDC power feed. Sensors shall have a minimum five (5) year battery life along with battery level indication reported through the BMS. Please reference Section 2.9.

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 and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.
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. 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.
6. Averaging Sensors
   a. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

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. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
   5. Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

D. 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. 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:
      ◊ -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
      ◊ 4-20 mA output.
      ◊ Maintain accuracy up to 20 to 1 ratio turndown.
      ◊ Reference Accuracy: +0.2% of full span.
   c. Acceptable Manufacturers: Johnson Controls and Setra.
3. 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:
      ◊ Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
      ◊ Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
      ◊ Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).
   b. Acceptable manufacturers: Johnson Controls and Setra.

E. Flow Monitoring

F. Status and Safety Switches
   1. General Requirements

a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS 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.

d. Acceptable manufacturers: Veris Industries

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.

d. Acceptable manufacturers: Johnson Controls, Cleveland Controls

2.8 OUTPUT DEVICES

A. Actuators

1. General Requirements

a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.

B. Control Dampers

1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.

2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60”. Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48”x48” size shall not leak in excess of 8.0 cfm per square foot when closed against 4” w.g. static pressure when tested in accordance with AMCA Std. 500.

C. 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.

f. Acceptable manufacturers: Johnson Controls, Lectro

D. Control Valves

1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer’s recommendations for the given application. In general, valves (2 or 3-way) serving **variable** flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving **constant** flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop

of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

4. Acceptable manufacturers: Johnson Controls

2.9 (OPTIONAL) WIRELESS DEVICES

A. General Requirements

1. All wireless communication shall utilize the BACnet ZigBee mesh protocol.

B. Temperature and Temperature/Humidity Sensors

1. Sensors shall include capability to measure and transmit temperature, humidity and occupancy override in combination without the use of separate sensors.

2. Sensors shall utilize two (2) AA batteries and shall not require a dedicated 24 VDC power feed.

3. Sensors shall have digital display capability.

4. Sensors shall have a minimum five (5) year battery life along with battery level indication reported through the BMS.

5. Sensors shall have LED indication of diagnostic information for use in commissioning and troubleshooting.

6. Wireless cooler/freezer temperature sensors shall be provided for use in cooler/freezer temperature monitoring as necessary.

C. Wireless Routers and Repeaters

1. Addressable, flag-type routers and repeaters shall be used to receive and transmit wireless communication.

2. Routers shall be connected and powered via the SA bus controller port. Repeaters shall require a separate 24V power supply.

D. Wireless Coordinators

1. Coordinators shall serve as end-of-line wireless devices for up to thirty-five (35) wireless-enabled controllers. Coordinators shall hard-wired downstream into the building communication bus.

3. PART 3 – PERFORMANCE / EXECUTION

3.1 BMS 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. Air Handling Equipment
   a. All air handers shall be controlled with a HVAC-DDC Controller
   b. All damper and valve actuation shall be electric.
3. Terminal Equipment:
   a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.
   b. All Terminal Units shall be controlled with HVAC-DDC Controller)

3.2 INSTALLATION PRACTICES

A. BMS Wiring (See Section J for wireless installation)

1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
2. All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
3. Class 2 Wiring
   a. Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
   b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
4. 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.

5. 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. BMS Line Voltage Power Source

1. 120-volt AC to control panels used for the Building Management System shall be provided by Division 16.
2. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.
3. DDC terminal unit controllers may use AC power from motor power circuits.

C. BMS Raceway

1. All wiring shall be installed in 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.

D. Penetrations

1. Provide fire stopping for all penetrations used by dedicated BMS 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.

E. BMS Identification Standards

1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

F. BMS Panel Installation

1. The BMS 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.

G. Input Devices

1. All Input devices shall be installed per the manufacturer recommendation
2. Locate components of the BMS in accessible local control panels wherever possible.

H. HVAC Input Devices – Genera1

1. All Input devices shall be installed per the manufacturer recommendation
2. Locate components of the BMS 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. 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.
7. Air Flow Measuring Stations:
   a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
   b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
8. 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.
9. Space Sensors:
   a. Shall be mounted per ADA requirements.

I. HVAC Output Devices

1. All output devices shall be installed per the manufacturers 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 Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
4. Control Valves: 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.

5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System 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

J. Wireless Installation

1. Prior to installation, wireless system functionality shall be ensured via field testing or floor plan analysis. When locating sensors, routers and repeaters, all signal-attenuating material shall be accounted and compensated for (e.g. metal, brick or concrete).
2. To ensure reliability, Contractor shall provide no fewer than two (2) downstream paths of communication per VAV or field controller. Wireless repeaters (requiring 24V power) shall be installed as needed to maintain wireless mesh integrity.
3. All wireless sensors (temperature and/or temperature plus humidity) shall be located as indicated on the drawings, but no greater than 50 ft. from the nearest wireless router.
4. All wireless routers shall be located on individual terminal or air-handling unit controllers as indicated on the drawings, but no greater than 50 ft. from the nearest wireless router or repeater.
5. Wireless coordinators shall be installed as end-of-line wireless devices no greater than 50 ft. from the nearest wireless router or repeater. Coordinators shall then be hard-wired into the building communication bus. Reference Section A.2 for wiring specifications.

3.3 TRAINING

A. The BMS contractor shall provide the following training services:

1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 COMMISSIONING

A. Fully commission all aspects of the Building Management System work.

B. Acceptance Check Sheet

1. Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.

2. Submit the check sheet to the Engineer for approval
3. The Engineer will use the check sheet as the basis for acceptance with the BMS Contractor.

C. VAV box performance verification and documentation:

1. The BMS Contractor shall test each VAV box for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.

D. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

END OF SECTION 230923

SECTION 230923.11

CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.
2. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Determine control valve sizes and flow coefficients by ISA 75.01.01.

E. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

F. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:

a. Chilled Water: 150psi 35°F - 140°F.

2. Fail positions unless otherwise indicated:

a. Chilled Water: Open.

3. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
4. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.
5. Modulating valve sizes for steam service shall provide a pressure drop at design flow equal to lesser of the following:

a. 50 percent of the valve inlet pressure.
b. 50 percent of the absolute steam pressure at the valve inlet.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:

1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.

5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: Chrome-plated brass or bronze.
8. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristic: Equal percentage.

B. Ball Valves with Two Ports and Characterized Disk:

1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: Chrome-plated brass or bronze.
8. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristics for A-Port: Equal percentage.
12. Flow Characteristics for B-Port: Modified for constant common port flow.

C. Pressure-Independent Ball Valves NPS 2 and Smaller:

1. Performance:

    a. Pressure Rating: 600 psig for NPS 1 and 400 psig for NPS 1-1/2 and NPS 2.

b. Close-off pressure of 200 psig.
c. Process Temperature Range: Between zero to 212 deg F.
d. Rangeability: 100 to 1.

2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:

1. Performance:

a. Bi-directional bubble tight shutoff at 250 psig.
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

2. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:

1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:

    a. Bi-directional bubble tight shutoff at 250 psig.
    b. Comply with MSS SP-67 or MSS SP-68.
    c. Rotation: Zero to 90 degrees.
    d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Body and trim materials.
    d. Flow arrow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:

    a. Manufacturer's name, model number, and serial number.
    b. Body and trim size.
    c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:

1. Globe Style: Single port.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.

4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass.
8. Process Temperature Range: 35 to 248 deg F.
9. Ambient Operating Temperature: 35 to 150 deg F.
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:

1. Globe Style: Mix flow pattern.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass.
8. Process Temperature Range: 35 to 248 deg F.
9. Ambient Operating Temperature: 35 to 150 deg F.
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Globe Style: Single port.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F.
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.

E. Industrial-Grade Straight-Through Globe Valves NPS 1 and Larger:

1. Globe Style: Single port.
2. Body: Cast iron or cast steel.
3. End Connections for NPS 2: Threaded.
4. End Connections for NPS 2-1/2 and Larger: Raised face flanged.
5. Bonnet: Bolted.

6. Packing: PTFE V-ring.
7. Plug: Cage guided and unbalanced.
8. Plug, Seat, and Stem: 416 stainless-steel plug and seat, 17-4 PH stainless-steel cage and 316 stainless-steel stem.
9. Valve Stem: Thread and pin stem to plug.
10. Valve Stem Finish: Polished to 5 microinches rms or less.
11. Plug and Seat Surfaces: Hardened facing.
12. Process Temperature Range: Zero to 450 deg F.
13. Ambient Operating Temperature: Minus 20 to plus 150 deg F.
14. Leakage: FCI 70-2, Class IV.
15. Flow Characteristic: Equal percentage.

2.5 SOLENOID VALVES

A. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.2 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: 24-V ac.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

I. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.

K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

   a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
   b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-V dc signals.
   c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
   d. Programmable Multi-Function:

      1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
      2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
      3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

L. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.

3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

R. Stroke Time:

1. Operate valve from fully closed to fully open within 15 seconds.
2. Operate valve from fully open to fully closed within 15 seconds.
3. Move valve to failed position within 5 seconds.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. Chilled Water System, Two-Way Applications Controlled by Flow: Ball valves with single port and characterized disk.
3. Chilled Water System,, Three Way, Controlled by Temperature: Ball valves with two ports and characterized disk.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required

for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 2.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 1.

F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

J. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

K. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

L. Install engraved phenolic nameplate with valve identification on valve and on face of ceiling directly below valves concealed above ceilings.

3.5 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12

CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

2.2 RECTANGULAR CONTROL DAMPERS

A. 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 assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

   a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft.gainst 1-in. wgifferential static pressure.
   b. Pressure Drop: 0.05-in. wgt 1500 fpmcross a 24-by-24-inchamper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 6000 fpmTemperature: Minus 40 to plus 185 deg FPressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
   d. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

   a. Frame:

      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles,0.07 inchhick.

      2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inchWidth not less than 5 inchesBlades:

      3) Hollow, airfoil, extruded aluminum.
      4) Parallel or opposed blade configuration as required by application.
      5) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inchhick.

      6) Width not to exceed 6 inchesLength as required by close-off pressure, not to exceed 48 inchesSeals:

      7) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
      8) Jambs: Stainless steel, compression type.

   b. Axles: 0.5-inch-eter plated or stainless steel, mechanically attached to blades.
   c. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

d. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

e. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inchesSleeve length shall be not less than 12 inchesor dampers without jackshafts and shall be not less than 16 inchesfor dampers with jackshafts.
4) Sleeve material shall match adjacent duct.

f. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inchthick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

3. Airflow Measurement:

a. Where indicated, provide damper assembly with integral airflow monitoring.
b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
c. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.
d. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
e. Suitable for operation in untreated and unfiltered air.
f. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
g. Provide automatic zeroing feature.

4. Airflow Control:

a. Where indicated, provide damper assembly with integral airflow measurement and control.
b. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
c. The controller and actuator shall communicate to control the desired airflow.
d. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.
e. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.Ambient Operating Temperature Range: Minus 40 to plus 140 deg FAmbient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.
f. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.Provide screw terminals for interface to field wiring.Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.Rectangular Dampers with Steel Airfoil Blades:

5. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft.against 1-in. wgdifferential static pressure.
b. Pressure Drop: 0.06-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm.
d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

6. Construction:

a. Frame:

1) Material: ASTM A 653/A 653M galvanized-steel profiles, 0.06 inch thick.
2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch.
3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, galvanized steel.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM A 653/A 653M galvanized steel, 0.05 inch thick.
4) Width not to exceed 6 inches.

5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:

1) Stainless steel mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide epoxy finish for surfaces in contact with airstream.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

C. Rectangular Dampers with Aluminum Flat Blades:

1. Performance:

a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.07-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.

c. Velocity: Up to 2000 fpm.
d. Temperature: Minus 50 to plus 250 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 3-in. wg.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles,0.12 inch thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches.

b. Blades:

1) Flat blades of extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles,0.12 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-iameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Rectangular Dampers with Steel Flat Blades:

1. Performance:

a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 1500 fpm.
d. Temperature: Minus 25 to plus 180 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel,0.06 inch thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches.

b. Blades:

1) Flat blades with multiple grooves positioned axially for reinforcement.
2) Parallel or opposed blade configuration as required by application.
3) Material: Galvanized or stainless steel, 0.06 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions:

1. Exhaust Air: Open.
2. Outdoor Air: Close.
3. Supply Air: Open.
4. Return Air: Open.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. See Drawings.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

   a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
   b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-V dc signals.

c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.

d. Programmable Multi-Function:

1) Control input, position feedback, and running time shall be factory or field programmable.
2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:

1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 5 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.
   c. Salt water environment.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."Section 16075 "Electrical Identification."

I. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.4 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.

2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 232113

HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:
   1. Chilled-water piping.
   2. Condensate-drain piping.
   3. Blowdown-drain piping.
   4. Air-vent piping.
   5. Safety-valve-inlet and -outlet piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

   1. Plastic pipe and fittings with solvent cement.
   2. RTRP and RTRF with adhesive.
   3. Pressure-seal fittings.
   4. Chemical treatment.

B. LEED Submittals:

   1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Chilled-Water Piping: 150 psig at 200 deg F.
   2. Makeup-Water Piping: 80 psig at 150 deg F.
   3. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L

B. Annealed-Temper Copper Tubing: ASTM B 88, Type KDWV tubing in "DWV Copper Tubing" Paragraph below is intended for nonpressure applications and is applicable for condensate drains.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
   1. Grooved-End Copper Fittings: ASTM B 75copper tube or ASTM B 584, bronze casting.
   2. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg For use with housing, and steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Grooved Mechanical-Joint Fittings and Couplings:
1. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
2. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.4 PLASTIC PIPE AND FITTINGS

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

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inchaximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
b. Adhesive primer shall have a VOC content of 550 g/L or less.

c. PVC solvent cement shall have a VOC content of 510 g/L or less.
d. Adhesive primer shall have a VOC content of 550 g/L or less.

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:
1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

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

B. Dielectric Unions:
1. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psi minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.8 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psigorking pressure; 5-gal.apacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

B. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
1. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Makeup-water piping installed aboveground shall be[**either of**] the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 80 CPVC plastic pipe and fittings, and solvent-welded joints.

D. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints when not in return air plenums.

E. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints, when not in return air plenum.

F. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

G. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," Section 230523.14 "Check Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 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 nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23054813 "Vibration and Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that

stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.2 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.3 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 230 psigtion Lines for Heat-Pump Applications: 380 psig-Gas and Liquid Lines: 380 psige Test Pressure for Refrigerant R-410A:

B. Copper Tube: ASTM B 88, Type K or LTM B 280, Type ACR.

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

F. Brazing Filler Metals: AWS A5.8/A5.8M.

G. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inchlignment in minimum 7-inch-bly.
4. Working Pressure Rating: Factory test at minimum 500 psigimum Operating Temperature: 250 deg FVES AND SPECIALTIES

H. ASHRAE 34, R-134a: Tetrafluoroethane.

I. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083100 "Access Doors and Panels" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.

3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

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

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232500

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual and automatic chemical-feed equipment and controls.
2. Ozone-generator biocide equipment and controls.
3. Stainless-steel pipes and fittings.
4. UV-irradiation unit, biocide equipment, and controls.
5. Chemical treatment test equipment.
6. Chemicals.
7. HVAC makeup-water softeners.
8. RO equipment for HVAC makeup water.
9. Water filtration equipment.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Closed hydronic systems shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.

3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.2 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.

B. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

C. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

D. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

    a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

E. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.

9. Biocide A and Biocide B pump running indication.

F. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 30 gal..

G. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

   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.

H. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

I. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three-piece stainless steel, as described in "Stainless-Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.3 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

Resin exchange capacity minimum 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.

2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install interconnecting control wiring for chemical treatment controls and sensors.

C. Mount sensors and injectors in piping circuits.

D. Bypass Feeders: Install in closed hydronic systems, including and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

E. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Where installing piping adjacent to equipment, allow space for service and maintenance.

G. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

H. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

I. See Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

J. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

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

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232500

SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
3. Section 015721 – Indoor Air Quality Controls.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. 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, 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 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

C. LEED Compliance: Protection of ductwork during construction must comply with requirements of Indoor Air Quality credit 3.1 Construction IAQ Management Plan, During Construction.

PART 2 - PRODUCTS

2.1 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 ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 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. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
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).

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).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-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.

2.5 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 233300 "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 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.

3.3 DUCT SEALING

A. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class 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.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. 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.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

E. 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.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.7 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive 2-inch wg.

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 3-inch wg.

b. Pressure Class: Positive 3-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 3-inch wg.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 2-inch wg.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 3-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 3-inch wg.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

    a. Pressure Class: Negative 3-inch wg.

2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive or negative 3-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 3-inch wg.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

    a. Pressure Class: Positive or negative 2-inch wg.

2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive or negative 3-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 3-inch wg.

E. Elbow Configuration:

1. 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."

2. 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) Radius-to Diameter Ratio: 1.5.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
    c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

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: 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 233113

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
3. Section 083100 ‘Access Doors and Panels”.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. 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.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: 3000 fpm.

C. Maximum System Pressure: 3-inch wg.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.03-inch-thick stainless steel, with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Neoprene, mechanically locked.

H. Blade Axles:

1. Material: Aluminum.
2. Diameter: 0.20 inch.

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or synthetic pivot bushings.

L. Accessories: Refer to drawings

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Suitable for horizontal or vertical applications.
2. Frames:

a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

3. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized-steel, 0.064 inch thick.

4. Blade Axles: Galvanized steel.

5. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

5. Blade Axles: Galvanized steel.

6. Tie Bars and Brackets: Aluminum.

2.5 CONTROL DAMPERS

A. Frames:

1. Hat shaped.
2. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.

B. Blades:

1. Multiple blade with maximum blade width of 6 inches.
2. Opposed-blade design.

C. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

2.6 FIRE DAMPERS

A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades inside airstream or Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.39 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.7 SMOKE DAMPERS

A. General Requirements: Label according to UL 555S by an NRTL.

B. Smoke Detector: Integral, factory wired for single-point connection.

C. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with mechanically attached corners.

D. Blades: Roll-formed, horizontal, interlocking, galvanized sheet steel.

E. Leakage: Class I.

F. Rated pressure and velocity to exceed design airflow conditions.

G. Mounting Sleeve: Factory-installed, 0.039-inch - thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

H. Damper Motors: Modulating action.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC"
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

J. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.

2.8 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

2.10 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

B. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.

5. Doors close when pressures are within set-point range.

2.11 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches 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.

D. 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.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.12 FLEXIBLE DUCTS

A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.14 CEILING ACCESS PANELS: Refer to plans for locations. If not shown, install ceiling access panels where needed to provide full access to all control devices above ceilings, at no additional cost to the Owner. Refer to Section 083100 “Access Doors and Panels”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

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. 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.
   2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. At outdoor-air intakes and mixed-air plenums.
   2. At drain pans and seals.

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. At each change in direction and at maximum 50-foot spacing.
6. Upstream from turning vanes.
7. Upstream or downstream from duct silencers.
8. Control devices requiring inspection.

I. Install access doors with swing against duct static pressure.

J. 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.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

N. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233423

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.
2. Ceiling-mounted ventilators.
3. In-line centrifugal fans.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: 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.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Housing: Removable, spun-aluminum, dome top and outlet baffle or extruded-aluminum, rectangular top; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

C. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

D. Accessories:

1. Variable-Speed 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 mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: Refer to drawings.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: 1/2-inch thick steel bars welded in place to form 6-inch squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: Unlined with louvered vents in vertical sides.

2.2 CEILING-MOUNTED VENTILATORS

A. Housing: Steel, lined with acoustical insulation.

B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

C. Grille Aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

D. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 IN-LINE CENTRIFUGAL FANS

A. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

B. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

C. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

2.5 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548.13 "Vibration Controls for HVAC."]

E. Install units with clearances for service and maintenance.

F. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 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. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 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. Verify that shipping, blocking, and bracing are removed.
2. 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.
3. Verify that cleaning and adjusting are complete.
4. 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.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

SECTION 233600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.
   2. Casing liner.

1.2 ACTION SUBMITTALS

A. Typically, submittals listed under "LEED Submittals" are those which are required to be uploaded to LEED On-line by the USGBC as supporting documentation to earn a particular credit. Unless this ASHRAE compliance documentation is required by LEED (or other purposes such as compliance with code, or QA/QC procedures), we would recommend deleting items 1 or moving it to its own subsection without the 'LEED Submittals' heading.

B. LEED Submittals:
   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

1.3 INFORMATIONAL SUBMITTALS

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

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: Double wall construction.
   1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   2. Air Outlet: S-slip and drive connections, size matching inlet size.
   3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Damper Position: Normally open.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. 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.

F. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

G. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

H. Control Sequences:

1. Occupied:

a. In a call for cooling, airflow will increase as the damper opens towards maximum setting to satisfy set point.
b. In a call for less cooling, airflow will decrease as the damper closes towards minimum setting to satisfy set point.

2. Unoccupied:

a. Damper closes to minimum maximum setting.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

D. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

E. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

F. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

G. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
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.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rectangular and square ceiling diffusers.
   2. Louver face diffusers.
   3. Linear slot diffusers.
   4. Fixed face registers and grilles.

B. Related Sections:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

   1. Devices shall be specifically designed for variable-air-volume flows.
   2. Material: Aluminum.
   3. Finish: Baked enamel, white.
   4. Face Size: Refer to drawings.
   5. Face Style: Refer to drawings.
   6. Mounting: Refer to drawings.
   7. Pattern: Refer to drawings.

8. Dampers: Radial opposed blade.

B. Louver Face Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Size: Refer to drawings.
5. Mounting: Refer to drawings.
6. Pattern: Refer to drawings.
7. Dampers: Radial opposed blade.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material - Shell: Aluminum.
3. Material - Pattern Controller and Tees: Aluminum.
4. Finish - Face and Shell: Baked enamel, black.
5. Finish - Pattern Controller: Baked enamel, black.
6. Finish - Tees: Baked enamel, white.
7. Slot Width: Refer to drawings.
8. Number of Slots: Refer to drawings.
9. Length: Refer to drawings.

2.3 REGISTERS AND GRILLES

A. Adjustable Bar Register:
1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Blade Arrangement: refer to drawings.
4. Rear-Blade Arrangement: refer to drawings.
5. Damper Type: Adjustable opposed blade.

B. Adjustable Bar Grille:
1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Blade Arrangement: refer to drawings.
4. Rear-Blade Arrangement: refer to drawings.

C. Fixed Face Register:
1. Material: Aluminum.
2. Finish: Baked enamel, white.
3. Face Arrangement: Refer to drawings.
4. Damper Type: Adjustable opposed blade.

D. Fixed Face Grille:
   1. Material: Aluminum.
   2. Finish: Baked enamel, white.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers, registers, and grilles 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, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233723

HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Roof hoods.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

1.3 ACTION SUBMITTALS

A. Typically, submittals listed under “LEED Submittals” are those which are required to be uploaded to LEED On-line by the USGBC as supporting documentation to earn a particular credit. unless, this ASHRAE compliance documentation is required by LEED (or other purposes such as compliance with code, or QA/QC procedures), we would recommend deleting this subsection, or revising the heading by deleting the word “LEED”.

B. LEED Submittals:

C. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

D. Samples: For each exposed product and for each color and texture specified.

1.4 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221 Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209 Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90zinc coating, mill phosphatized.

D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use hex-head or Phillips pan]-head screws for exposed fasteners unless otherwise indicated.

E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

2.3 LOUVERED-PENTHOUSE VENTILATORS

A. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch for frames and 0.080 inch for blades.

   1. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.

B. Bird Screening: Aluminum, 1/2-inch-square mesh, 0.063-inch wire.

2.4 ROOF HOODS

A. Factory fabricated according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.

B. Materials: Aluminum sheet, minimum 0.063-inch-ick base and 0.050-inch-ick hood; suitably reinforced.

C. Bird Screening: Aluminum, 1/2-inch-uare mesh, 0.063-inchwire.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Secure gravity ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealers" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

END OF SECTION 233723

SECTION 236423

SCROLL WATER CHILLERS

1. GENERAL

1.01. GENERAL REQUIREMENTS

The requirements of this Section shall conform to the general provisions of the Contract, including General and Supplementary Conditions, Conditions of the Contract, and Contract Drawings.

1.02. SCOPE

Provide Microprocessor controlled, multiple scroll compressor, air-cooled, liquid chillers of the scheduled capacities as shown and indicated on the Drawings, including but not limited to:

1. Chiller package
2. Charge of refrigerant and oil
3. Electrical power and control connections
4. Chilled liquid connections
5. Manufacturer start-up

1.03. QUALITY ASSURANCE

A. Products shall be Designed, Tested, Rated and Certified in accordance with, and Installed in compliance with applicable sections of the following Standards and Codes:
   1. AHRI 550/590 – Water Chilling Packages Using the Vapor Compression Cycle
   2. AHRI 370 – Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
   3. ANSI/ASHRAE 15 – Safety Code for Mechanical Refrigeration
   4. ANSI/ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
   5. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
   6. ANSI/NFPA 70 – National Electrical Code (N.E.C.)
   7. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
   8. OSHA – Occupational Safety and Health Act
   9. Manufactured in facility registered to ISO 9001
   10. Conform to Intertek Testing Services for construction of chillers and provide ETL/cETL Listed Mark

B. Factory Run Test: Chiller shall be pressure-tested, evacuated and fully charged with refrigerant and oil, and shall be factory operational run tested with water flowing through the vessel.

C. Chiller manufacturer shall have a factory trained and supported service organization.

D. Warranty: Manufacturer shall Warrant all equipment and material of its manufacture against defects in workmanship and material for a period of eighteen (18) months from date of shipment or twelve (12) months from date of start-up, whichever occurs first.

1.04. DELIVERY AND HANDLING

A. Unit shall be delivered to job site fully assembled with all interconnecting refrigerant piping and internal wiring ready for field installation and charged with refrigerant and oil by the Manufacturer.

B. Provide protective covering over vulnerable components for unit protection during shipment. Fit nozzles and open ends with plastic enclosures.

C. Unit shall be stored and handled per Manufacturer's instructions.

2. PRODUCTS

2.01. CHILLER MATERIALS AND COMPONENTS

A. General: Install and commission, as shown on the schedules and plans, factory assembled, charged, and tested air cooled scroll compressor chiller(s) as specified herin. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD 34 Number Designation and Safety Classification of Refrigerants. Chiller shall include not less than two refrigerant circuits above 50 tons (200kW), scroll compressors, direct-expansion type evaporator, air-cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components and special features as specified herin or required for safe, automatic operation.

B. Cabinet: External structural members shall be constructed of heavy guage, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5% salt spray test, yields minimum ASTM 1654 rating of "6".

C. Operating Characteristics: Provide low and high ambient temperature control options as required to ensure unit is capable of operation from 30°F to 115°F (-1°C to 46°C) ambient temperature. [Optional: 0°F to 125°F (-18°C to 52°C) ambient.]

D. Service Isolation valves: Discharge (ball type) isolation valves factory installed per refrigerant circuit. Includes a system high-pressure relief valve in compliance with ASHRAE15.

E. Pressure Transducers and Readeout Capability

1. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.

2. Suction Pressure Transducers: Permits unit to sense and display suction pressure.
3. High Ambient Control: Allows units to operate when the ambient temperature is above 115°F (46°C). Includes discharge pressure transducers

2.02. COMPRESSORS

A. Compressors: Shall be hermetic, scroll-type, including:

1. Compliant design for axial and radial sealing.
2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low-pressure drop, silent shutdown and reverse rotation protection.
6. Initial oil charge.
7. Oil level sight glass.
8. Vibration isolator mouonts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.
10. Compressor Motor overloads capable of monitoring compressor motor current. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

2.03. REFRIGERANT CIRCUIT COMPONENTS

Each refrigerant circuit shall include: a discharge service ball type isolation valve, high side pressure relief, liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, sight glass with moisture indicator, electronic expansion valves, and flexible, closed-cell foam insulated suction line and suction pressure transducer.

2.04. HEAT EXCHANGERS

A. Evaporator:

1. Evaporator shall be brazed-plate stainless steel construction capable of refrigerant working pressure of 650 psig (3103 kPa) and liquid side pressure of 150 psig (1034 kPa) [Option for 300 psig (2068 kPa) available].
2. Brazed plate heat exchangers shall be UL listed.
3. Exterior surfaces shall be covered with 3.4" (19mm), flexible, closed cell insulation, thermal conductivity of 0.26k ([BTU/HR-Ft² - °F]/in.) maximum.
4. Water nozzles shall be provided with grooves for field provided ANSI/AWWA C-606 mechanical couplings.
5. Evaporator shall include vent and drain fittings and thermostatically controlled heaters to protect to -20°F (-29°C) ambient in off-cycle.

6. A 20-mesh, serviceable wye-strainer and mechanical couplings shall be provided for field installation on evaporator inlet prior to startup.

B. Air-cooled Condenser:

1. Coils: Condenser coils shall be constructed of a single material to avoid galvanic corrosion due to dissimilar metals. Coils and headers are brazed as one piece. Integral sub cooling is included. Coils shall be designed for a design working pressure of 650 PSIG (45 bar). Condenser coil shall be washable with potable water under 100 psi (7 bar) pressure.
2. Low Sound Fans: Shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise, full-airfoil cross section, providing vertical air discharge and low sound. Each fan shall be provided in an individual compartment to prevent crossflow during fan cycling. Guards of heavy gauge, PVC (poly- vinylchloride) coated or galvanized steel shall be factory installed.
3. Fan Motors: High efficiency, direct drive, 6 pole, 3 phase, insulation class "F", current protected, Totally Enclosed Air-Over (TEAO), rigid mounted, with double sealed, permanently lubricated, ball bearings.

2.05. CONTROLS

A. General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.

B. Power/Control Enclosure: Rain and dust tight NEMA 3R powder painted steel cabinet with hinged, latched, and gasket sealed door.

C. Microprocessor Control Center:

1. Automatic control of compressor start/stop, anti-coincidence and anti-recycle timers, automatic pumpdown at system shutdown, condenser fans, evaporator pump, evaporator heater, unit alarm contacts, and chiller operation from 0°F to 125°F (-18°C to 52°C) ambient. Automatic reset to normal chiller operation after power failure.
2. Software stored in non-volatile memory, with programmed setpoints retained in lithium battery backed real-time-clock (RTC) memory for minimum 5 years.
3. Forty character liquid crystal display, descriptions in English (or Spanish, French, Italian, or German), numeric data in English (or Metric) units. Sealed keypad with sections for Setpoints, Display/Print, Entry, Unit Options & clock, and On/Off Switch.
4. Programmable Setpoints (within Manufacturer limits): display language; chilled liquid temperature setpoint and range, remote reset temperature range, daily schedule/holiday for start/stop, manual override for servicing, low and high ambient cutouts, low liquid temperature cutout, low suction pressure cutout, high discharge pressure cutout, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).

5. Display Data: Return and leaving liquid temperatures, low leaving liquid temperature cutout setting, low ambient temperature cutout setting, outdoor air temperature, English or metric data, suction pressure cutout setting, each system suction pressure, liquid temperature reset via a 4-20milliamp or 0-10 VDC input, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves, evaporator heater and fan operation, run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
6. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. System Safeties include: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
7. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation.
8. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.
9. BAS Communications: YORKTalk 2, BACnet MS/TP, Modbus and N2 communication capabilities are standard.

D. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

2.06. POWER CONNECTION AND DISTRIBUTION

A. Power Panels:
1. NEMA 3R/12 rain/dust tight, powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connection(s), control power connections, compressor and fan motor start contactors, current overloads, and factory wiring.
2. Power supply shall enter unit at a single location, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor. Separate disconnecting means and/or external branch circuit protection (by Contractor) required per applicable local or national codes.

B. Compressor, control and fan motor power wiring shall be located in an enclosed panel or routed through liquid tight conduit.

2.07. ACCESSORIES AND OPTIONS

Some accessories and options supersede standard product features. Your Johnson Controls representative will be pleased to provide assistance.

A. Microprocessor controlled, Factory installed Across-the-Line type compressor motor starters as standard.

B. Outdoor Ambient Temperature Control

C. Power Supply Connections:

1. Single Point or Multiple Point Disconnect: Single or Dual point Non-Fused Disconnect(s) and lockable external handle (in compliance with Article 440-14 of N.E.C.) can be supplied to isolate the unit power voltage for servicing. Separate external fusing must be supplied, by others, in the incoming power wiring, which must comply with the National Electric Code and/or local codes.

D. Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory-mounting includes primary and secondary wiring between the transformer and the control panel.

E. Condenser Coil Environmental Protection (Factory applied):

1. Post-Coated Dipped: Dipped-cured coating on condenser coils for seashore and other corrosive applications (with the exception of strong alkalis, oxidizers, and wet bromine, chlorine and fluorine in concentrations greater than 100 ppm).

F. Protective Chiller Panels (Factory)

1. Louvered/Wire Panels: Louvered steel panels on external condenser coils painted as per remainder of unit cabinet. Heavy gauge, welded wire-mesh, coated to resist corrosion, around base of machine to restrict unauthorized access.

G. Evaporator options:

1. Provide 1-1/2"" evaporator insulation in lieu of standard 3/4".

H. Sound Reduction (Factory installed):

1. Ultra Quiet - Low speed, reduced noise fans
2. Compressor Acoustic Sound Blankets

I. Vibration Isolation (Field installed):

1. 1" Deflection Spring Isolators: Level adjustable, spring and cage type isolators for mounting under the unit base rails.

3. EXECUTION

3.01. INSTALLATION

A. General: Rig and Install in full accordance with Manufacturer's requirements, Project drawings, and Contract documents.

B. Location: Locate chiller as indicated on drawings, including cleaning and service maintenance clearance per Manufacturer instructions. Adjust and level chiller on support structure.

C. Components: Installing Contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.

D. Electrical: Coordinate electrical requirements and connections for all power feeds with Electrical Contractor (Division 26).

E. Controls: Coordinate all control requirements and connections with Controls Contractor.

F. Finish: Installing Contractor shall paint damaged and abraded factory finish with touch-up paint matching factory finish.

END OF SECTION 230513

SECTION 237313

MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-zone air-handling units.
2. Multizone air-handling units.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. York, Trane, McQuay

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type II.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.

    a. Liner Adhesive: Comply with ASTM C 916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.

3. Location and Application: Encased between outside and inside casing.

C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

    a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

    a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
    b. Gasket: Neoprene, applied around entire perimeters of panel frames.

4. Locations:

    a. Fan Section.
    b. Access Section.
    c. Coil Section.
    d. Damper Section.
    e. Filter Section: large enough to allow periodic removal and installation of filters.
    f. Mixing Section.
    g. Humidifier Section.

D. Condensate Drain Pans:

1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
    b. Depth: A minimum of 2 inches deep.

E. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

        1) Fabric Minimum Weight: 26 oz./sq. yd..
        2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
        3) Fabric Service Temperature: Minus 40 to plus 200 deg F.

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

D. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

F. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 120,000 hours according to ABMA 9.
2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing and a rated life of 120,000 hours according to ABMA 11.
3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

G. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
1. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
2. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

H. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.

I. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
3. 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.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior of unit.

2.4 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

2.6 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

2.7 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

D. Refrigerant Coils: Factory tested to 450 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install air-handling units 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."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Install piping adjacent to air-handling unit to allow service and maintenance.

G. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

H. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

I. Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

J. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

END OF SECTION 237313

SECTION 238123.11

COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS (6 TONS AND SMALLER)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes floor-mounted, computer-room air conditioners of 6 tons and smaller.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. 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.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 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 five years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Data Aire, Liebert.

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. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

B. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch-thick duct liner.
   1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
   2. Unit with powder-coated insulated air distribution plenum.

C. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.

D. Refrigeration System:

   1. Compressor: Hermetic Scroll,

   2. Refrigerant: R-410A.
   3. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
   4. Refrigerant line sets.
   5. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.

      a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

   6. Remote Air-Cooled Refrigerant Condenser:

      a. Integral, copper-tube aluminum-fin coil.
      b. Condenser with transient voltage surge suppression and locking disconnect in the enclosed electrical panel section.
   7. Fan: Direct-drive, variable-speed centrifugal type.

E. Electric-Resistance Reheat Coil:

   1. Finned-tube electric elements with contactor and high-temperature-limit switches.
   2. SCR to proportionally control the reheat elements providing precise temperature control.

F. Filter: 4-inch- thick, disposable, pleated, glass-fiber media.
   1. MERV: 8 according to ASHRAE 52.2.

G. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

   1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
   2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.

3. Drain Cycle: Field-adjustable drain duration and drain interval.

H. Control System:

1. Microprocessor unit-mounted panel.
2. Fan contactor.
3. Compressor contactor.
4. Compressor start capacitor.
5. Control transformer with circuit breaker.
6. Solid-state temperature- and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.
12. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

I. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

PART 3 - EXECUTION

3.1 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 coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances.

D. Computer-Room Air-Conditioner Mounting: Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Air-Cooled Refrigerant Condenser Mounting: Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.2 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. Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. 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.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 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 238123.11

SECTION 238219

FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ductless fan coil units and accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

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

C. Samples: For units with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTLESS FAN COIL UNITS

A. Manufacturers: JCI, Envirotec, IEC Fan coils.

B. Coil Section Insulation: 1/2-inch foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.

D. Chassis: Galvanized steel where exposed to moisture, with powder-coat finish and removable access panel. Floor-mounting units shall have leveling screws.

E. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

1. MERV Rating: 6 when tested according to ASHRAE 52.2.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

H. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

I. Fan and Motor Board: Removable.

J. Factory, Hydronic Piping Package:

1. Provide a standard factory assembled valve piping package to consist of a 2 or 3 way, on/off, motorized electric control valve and two ball isolation valves. Control valves are piped normally closed to the coil. Maximum entering water temperature on the control valve is 200°F, and maximum close-off pressure is 25 PSIG. Maximum operating pressure shall be 300 PSIG.

2. Piping package shall be completely factory assembled, including interconnecting pipe, and shipped separate from the unit for field installation on the coil, so as to minimize the risk of freight damage.

K. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and drawings

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23054813 "Vibration Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

F. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.3 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. 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.

END OF SECTION 238219

SECTION 260010

BASIC ELECTRICAL GENERAL REQUIREMENTS

PART 1 GENERAL

1.1 This section is supported by the requirements of all other Contract Documents.

1.2 SUMMARY

A. This Section governs general procedures and work applicable to Divisions 21, 22, 23, 26, 27 and 28 and to certain equipment and work in Divisions 1, 2, 3, 7, 9 & 10.

1. Furnish labor, supervision, energy, materials, tools, transportation, equipment, permits (if required), insurance, taxes, temporary protection and correction necessary to provide work shown and specified.

2. Provide apparatus, appliances, material or work not shown on drawings but mentioned in specifications, or vice versa, and any incidental accessories necessary to make work complete and ready for operation or inspection by inspecting authorities, even if not specified, without additional expense to Owner.

3. Include minor details not usually shown or specified, but necessary for proper installation and operation, the same as if specified. In cases where apparatus is referred to in singular numbers, it is intended that such reference include as many such items as are required to complete work.

4. Provide conduit, wiring, and miscellaneous accessories necessary for complete installation of and final connections to equipment furnished by Owner, if any, and by other trades.

1.3 RELATED SECTIONS

1. Cutting and Patching.

2. Contract Closeout.

3. Flashing (except cap flashing for roof equipment and ducts).

4. Painting of exposed surfaces including color code painting of piping and conduit.

5. Access panels.

6. Motor power and control wiring.

1.4 WORK NOT INCLUDED

A. Equipment and wiring provided by local Telephone utility and local Power and Light utility.

1.5 DRAWINGS

A. Drawings are diagrammatic and indicate general arrangement of systems and work.

1. Do not scale drawings.

2. Consult architectural drawings, shop drawings and details for exact locations of fixtures, thermostats and equipment.

a. Where these are not definitely located, obtain this information from Project Architect/Engineer in writing prior to any rough-in.

B. Follow drawings in laying out work.

1. Check drawings of other trades to verify spaces in which work will be installed.

2. Maintain maximum headroom clearances and space conditions at all points as required by local codes and regulations.

3. Where headroom or space conditions appear inadequate, obtain instructions from Project Architect/Engineer before proceeding with installation.

C. Make reasonable modifications, without extra charge to Owner, in layout as needed to prevent conflict with work of other trades or for proper execution of work.

D. Engineering drawings are schematic for special equipment since exact dimensions and roughing-in requirements may vary with different manufacturers.

1.6 COOPERATION WITH OTHER TRADES

A. Schedule work and provide temporary service and connections for other trades.

B. Schedule work and provide temporary service and connections so existing systems will not be interrupted when they are required for usage of the existing building(s). Obtain written approval from the Owner at least 14 days prior to any interruption or connection.

C. Perform work at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.

D. Make all arrangements with the utility company for connecting the new services and providing all temporary services.

E. Field painting of exposed conduit and hangers is specified in the Section entitled PAINTING. Clean all surfaces and hanger rods free of grease, scale, rust and other foreign matter ready for painting. Touch up all factory finished, marred in construction, with factory touch-up kits.

F. Correct, without extra charge, electrical work installed in such a manner to cause interference with work of other trades, or to cause unacceptable clearance problems.

1.7 SHOP DRAWINGS AND PRODUCT DATA

A. Shop drawing requirements are specified in the General Conditions of the Contract for Construction.

1. Do not ship apparatus or equipment from stock or fabricate until shop drawings have been accepted by Project Engineer.

2. Submit shop drawings with pertinent data and with identification mark numbers specified or scheduled.

3. Shop drawings without identifications mark numbers or with incomplete performance information will not be reviewed until submission is complete.

B. Submit shop drawings, or product data where permitted, for the following:

1. Shop drawings of switchgear, switchboards, panelboards, transformers, lighting fixtures, wiring and cable, raceways and wireways, outlet, pull and junction boxes, wiring devices, disconnect switches, fuses and circuit breakers, lightning protection, generator set, sub-base-tank, automatic transfer switch(s) and fire alarm system.

2. Catalog cuts without shop drawings are not acceptable.

3. Submit 1/2" scale layout drawings for main electrical equipment spaces such as closets, switchgear rooms, major conduit bank runs and vaults. Submit layout drawings for review prior to installation of the work.

1.8 RECORD DRAWINGS

A. Keep accurate notes on record drawings of work as actually installed from work as originally indicated, paying particular attention to dimensioning of outside underground lines, their offsets and box locations.

1.9 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

A. Upon completion of work and of tests, provide necessary skilled labor and helpers for operating systems and equipment for a period of 3 days of 8 hours each. Instruct Owner's authorized representative(s) in operation, adjustment and maintenance of systems and equipment. Give Owner at least 48 hours notice of proposed instruction period.

B. Before date of Acceptance Inspection, prepare in reproducible form, detailed operating and maintenance manuals for installed equipment and systems.

1. Operating and maintenance manuals shall be used for training of and use by Owner's operating personnel in operation and maintenance of equipment and Electrical systems.

2. Manuals shall address equipment, operation of systems and equipment and parts replacement.

C. Furnish separate manual or chapter for each class of system:

1.10 SUPERVISION

A. Each subcontract trade shall provide services of an experienced superintendent, who shall be constantly in charge of installation of the work.

1.11 INSPECTIONS PRIOR TO OWNER'S ACCEPTANCE INSPECTION

A. Arrange and schedule as many inspections of work as may be necessary and, when appropriate, notify Project Architect/ Engineer, in writing, that safety-to-life systems are functioning in accordance with specifications.

1.12 CERTIFICATES

A. On completion of work, obtain certificates, if required, of compliance, approval or acceptance from authorities having jurisdiction over work and deliver these certificates to Project Architect.

1.13 MANUFACTURER'S NAMEPLATES

A. Each major component of equipment shall have manufacturer's name, address, model number and rating on a plate securely affixed in a conspicuous place.

B. Nameplate of a distributing agent will not be acceptable.

1.14 ACCEPTANCE

A. Operation of mechanical and electrical work by Contractor does not constitute acceptance of work. Acceptance will occur after Contractor has adjusted equipment,

demonstrated that it fulfills requirements of specifications and drawings, corrected defects, and has furnished all of required certificates, if any.

1.15 SPECIAL WARRANTIES

A. Manufacturer's Equipment and System Warranties: Provide manufacturer's written warranties which become a part of Contractor's responsibility to Owner in accordance with General Conditions of the Contract for Construction.

B. Manufacturer's Service: Provide manufacturer's service agreements, where required elsewhere in Sections of these specifications.

C. Contractor's Corrections of Work:

1. In addition to foregoing special warranties, any warranties made by Subcontractors to the Contractor are a part of the Contractor's responsibility to the Owner in accordance with General Conditions of the Contract.

2. Correction of work shall include shipping, labor, supervision and related work involved in replacing defective parts or materials provide by manufacturer's under their warranties.

1.16 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver products to job site in manufacturer's original unopened crates or containers, clearly labeled with manufacturer's name, product number and brand. Repair damage sustained by product(s) in transit and handling. If damage sustained while transporting products to job site is unrepairable, replace the product(s) at no cost to Owner.

B. Store and protect materials and equipment to prevent damage of any kind. Keep products dry at all times. Protect exposed metal surfaces with a light oil or silicone coating to prevent rust while in storage.

C. Handle products in such a manner to prevent breakage of containers and damage of any kind.

D. Schedule delivery of materials to job site in accordance with requirements of job progress to avoid delaying work.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equivalent required for work shall be new, of good quality, furnished,

delivered, erected, connected and finished in every detail, selected and arranged to fit properly into building spaces. Where no specific kind or quality of material is given, provide a good quality standard article as accepted by Project Architect/Engineer.

B. Equipment shall be of type and capacity shown on equipment schedules on drawings and in specifications and shall be as manufactured by one of manufacturers designated or equivalent, accepted in advance by Project Architect/Engineer.

C. For ease of maintenance and parts replacement, use equipment from a single manufacturer to maximum extent possible.

D. Equipment, materials and components shall be new, standard current products of manufacturers regularly engaged in production of such equipment and shall be manufacturer's latest design conforming to specifications. Materials shall be accepted by code enforcing authorities. Materials used in fire rated construction and in electrical work shall be UL listed, with UL labels as specified.

E. Hardware and accessory fitting shall be U.S. Standard sizes designed, intended or appropriate for the use, and complimenting items with which they are used. Furnish with corrosion protection suitable for the atmosphere in which they are installed.

F. Conform to Requirements of General Conditions of the Contract for Construction for coordinating space requirements, mounting arrangement(s) and service connections when substitute equipment is furnished instead of that used as a basis for design. Ascertain before ordering that equipment will fit assigned space and that it can be moved into position without interference from other construction, i.e., check door clearances, ceiling heights, crane access and the like. Be responsible for expenses generated by substitution of equipment used as a basis for design. Maintain clearances as required by the N.E.C.

2.2 IDENTIFICATION OF ELECTRICAL SYSTEM ITEMS

A. Identify electrical equipment and conductors in accordance with following:

1. Distribution Equipment: Major components of distribution system such as circuit breakers, switches, switchboards, panelboards, switchgear shall have nameplates with equipment identification, voltage and phase ratings and source of feed or circuit utilization. Equipment identification shall correspond to the designation on single line diagram. Panelboards shall have typed directories.

2. Starters, Disconnect Switches and Controls: Provide laminated phenolic nameplates with white letters on a black field secured with flush fastenings identifying equipment served.

3. Conductors: Color code wire and cable for feeders and branch circuits as follows unless otherwise required by local codes or electric utility company.

PHASE	208Y/120V
A	Black
B	Red
C	Blue
Neutral	White
Ground	Green

4. Ground Fault Protected Devices:

   a. Identify devices protected by ground fault interrupters.

   b. Receptacles, not otherwise identified by manufacturer, shall have cover plates with words "Protected by GFI" and "Test Before Using" engraved thereon.

2.3 UNDERWRITERS' LABORATORIES LISTING AND LABELS

A. Where materials and equipment are available under continuing inspection and labeling of UL, provide such material and equipment.

B. Listing by Underwriters' Laboratories shall be evidenced by label or:

UL - Electrical Construction Materials List (Green Book).
UL - Electrical Appliance and Utilization Equipment List.
UL - Building Materials List.

PART 3 EXECUTION

3.1 INSPECTION

A. Verify/examine that the surfaces, substrates, and conditions are satisfactory to receive electrical general provisions, and are free from deviations/defects affecting quality of the work.

B. Notify Contractor in writing of conditions detrimental to proper/timely completion of the work.

C. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.

D. Beginning of installation will be construed as acceptance of existing substrates, surfaces, and conditions.

3.2 EQUIPMENT INSTALLATION

A. Obtain services of manufacturer's representatives of major electrical equipment at job site during erection or construction of their equipment to insure proper installation. Failure to have such checks made by manufacturers shall place full responsibility for proper installation on Contractor who shall make any corrections or remedy defects at no additional cost to Owner.

B. Where necessary to meet space conditions bring equipment to its ultimate location in pieces or otherwise disassembled, then assemble it in place. Provide flanges, studs and the like for matching, alignment and field assembly.

C. Conduct field tests of equipment after assembly and during under direct supervision of manufacturer's representative. Upon satisfactory conclusion of field tests, manufacturer shall furnish, for each such apparatus or equipment, a written statement certifying that there has been neither invalidation of any warranties or guaranties, nor impairment of capacity or functioning of apparatus or equipment. Field tests shall be in addition to all factory tests, shop tests and final tests and adjustments.

D. Avoid field assembly wherever possible by suitable scheduling of the general construction work.

1. Extra compensation will not be allowed for those cases where it is necessary to field assemble equipment or apparatus.

3.3 FABRICATION AND INSTALLATION

A. Workers: Use thoroughly trained and experienced workers, completely familiar with items to be installed and manufacturer's current recommended methods of installations.

B. Set equipment level, properly aligned and bolted together where in sections. Secure equipment and materials firmly in place. Screws, bolts, nuts, clamps, fittings or other fastening devices shall be made up tight.

C. Repair to a new condition, or replace materials damaged during delivery, storage or installation. Touch-up scratched or marred finishes on equipment to match original finish or completely refinish.

D. Factory paint or finish enclosures, panels, cabinets, relays, safety switches, fixtures and other exposed equipment or accessories except as indicated otherwise. Group mounted items shall be similar in finish and color.

E. Make connections for air conditioning and ventilating equipment and controls. Follow manufacturers recommendations and system requirements when no other information available.

F. Support electrical raceways, conduits and light fixtures from overhead structure, not from ducts, pipes, conduits or the like. Support piping and HVAC ducts from overhead structure, not from ducts, pipes, conduits or equipment.

G. In order to use same means of support for electrical and mechanical items, design combined support system and coordinate to safely support suspended items.

3.4 HOUSEKEEPING

A. Clean exposed surfaces raceways and equipment which have become covered with dirt, plaster or other material during handling and construction before such surfaces are prepared for painting or enclosed within building structure,

B. Keep raceway openings closed by means of plugs or caps to prevent entrance of foreign matter.

1. Cover fixtures, equipment and apparatus to protect them against dirt, water, chemical or mechanical damage both before and after installation.

2. Damaged fixtures, equipment or apparatus shall be restored to its original condition or replaced at no cost to Owner.

3.5 EXCAVATION AND BACKFILLING

A. Excavation, backfilling and compaction of trenches required for the installation of electrical services and to points of connection with exterior underground utilities outside of the building shall be performed as specified in Trenching, Backfilling and Compaction for Utilities - Refer to Division 2 sections.

3.6 SLEEVES BLOCKOUTS, CUTTING AND PATCHING, CORING AND DRILLING

A. Sleeves:

1. All conduits passing through concrete slabs shall be provided with sleeves.

2. All conduits passing through interior concrete or masonry walls and partitions shall be provided with sleeves.

3. Where pipe motion due to expansion and contraction will occur, sleeves shall be of sufficient diameter to permit free movement of pipe.

B. Cutting and Patching:

1. Cut and patch as needed for installation of electrical equipment. Perform finish patching according to specifications for each finish, by mechanics skilled in each type finish.

2. Install work so that no undue cutting and patching will be required in building construction. Do no cutting that may impair strength of building construction. Install work in various portions of building as construction progresses. Do not delay construction of building.

3. Cut and patch as needed for conduits where sleeves and inserts were not installed, or where incorrectly located.

4. Provide for cutting out holes in structural steel webs (number, size and location) by means of shop drawing submittal and review only as approved by Project Architect/Engineer. Reinforce holes as directed by Project Architect/Engineer.

C. Coring and Drilling:

1. If a sleeve is omitted, core drill to permit insertion of a pipe sleeve with sufficient clearance to permit grouting in place with specified backer rod and sealant space between the line and sleeve.

2. When core drilling or cutting duct holes in foundations, walls, beams, columns or structural slabs, determine the location of reinforcement and tendons before coring.
3. Holes, except for small screws, may not be drilled in beams or other structural members, without obtaining prior acceptance of Project Architect/Engineer.

3.7 WATERPROOFING AND ROOFING

A. Where electrical work penetrates building envelope, or any waterproofed construction, method of installation shall be performed in a manner to prevent transmission of water, heat, cold and drafts.

B. Follow details, including architectural, which establish types of waterproofing construction for each penetration condition.

C. Where a detail suitable to encountered condition is lacking, request instructions from Project Architect/Engineer.

D. Provide necessary sleeves, sealing and flashing required to make opening watertight

3.8 FINAL TESTING, ADJUSTMENTS AND ACCEPTANCE OF ELECTRICAL EQUIPMENT AND SYSTEMS

A. Schedule testing and cleared through Project Architect/Engineer.

1. No testing of any kind shall be done or scheduled without clearance by Project Architect/Engineer.

2. Furnish Project Architect/Engineer with name of person who will be in charge of testing, energizing and start-up.

3. Confer with Project Architect/Engineer on procedures to be followed in obtaining clearances for electrical equipment.

4. Procedures as finally agreed upon shall be adhered to.

B. Complete test and inspection records shall be made and incorporated into a report for each piece of equipment tested. Record readings taken. Submit four copies to Project Architect for review.

C. Notify Project Architect in writing at least one week prior to test, establishing time that test is to be performed.

1. Perform tests in presence of Project Architect/Engineer.

D. Furnish necessary meters, instruments, temporary wiring and labor to perform required tests and adjustments of equipment and wiring including electrical equipment furnished by others, to determine proper polarity, phasing, freedom from grounds and shorts and operation of equipment. Measuring instruments shall be properly calibrated.

E. Demonstrate materials and manner of installation to be in accordance with the requirements of state and local public authorities, the utility company and NFPA.

F. Energize equipment following established procedures after certification by the Contractor that the installation is satisfactory.

G. Wiring:

1. Check system and equipment grounds for resistance using the Megger ground tester in accordance with manufacturer's instructions. Investigate circuits showing insulation resistance less than minimum values given in N.E.C. Correct weak points.

2. Overall resistance of the ground system shall be no greater than 25 ohms. Inspect grounding system to insure that above-ground cables and connections

are suitably protected. Provide additional ground rod, if needed, to obtain the specified resistance.

3. Make ground resistance tests at test points designated by the Project Architect/Engineer. Make ground resistance tests in accordance with James G. Biddle Company Bulletins 25T2 and 25-J.

4. Correct or replace nominal current-carrying circuits which are defective or grounded. Correct other troubles encountered in these tests.

H. Breakers: Set breakers so equipment will be in proper operating condition before being placed in service. Perform final operational tests to determine that wiring connections are correct.

I. Lighting:

1. Check lighting fixtures and receptacles for proper operation. At completion of work, clean fixtures and lenses and replace missing and burned out lamps.

J. Motors:

1. Make these tests on motors before start-up: Check motor nameplates for HP, speed, phase and voltage. Check bearings to see if they are filled with oil or grease. Lubricate. Check coupling alignment and shaft end-play.

2. Make these tests on motors during start-up:

a. Check shaft rotation before final connections are made. Check for bearing temperature and smooth operation.

b. Take a current reading at full load using a clamp-on ammeter. If ammeter is over the rated full load current, determine reason for the discrepancy and take corrective action.

3. After all connections are made, test motors and equipment for proper operation. Investigate cause of any motor operating above full load rating and remove cause, or report to Project Architect/Engineer instead of increasing overload heater rating. Check rotation of motors.

4. Check overload elements in motor starters for suitability to the motor characteristics. Replace any overload element that does not conform to starter manufacturer's recommendations based on actual nameplate current rating of the motor. Investigate the cause of any motor operating above full load rating and correct. Under no circumstances shall oversize overload relay trip rating be substituted.

K. Transformers: Megger winding insulation resistance, primary and secondary-to-ground and primary-to-secondary. Windings shall exhibit resistance in megohms equal to eight times the voltage rating of the winding in kV.

L. Control and Alarms: Check control and alarm circuits for proper operation. Test switchgear, switchboards, fire alarm system, as specified in each Section.

M. Service Voltage: Check service voltage at no-load and at full load on the distribution system. The objective shall be to maintain the equipment terminal voltage at less than 10% above nameplate rating at full system load. Then set transformer no-load taps so that at normal loading the average operating voltages at the terminals of all utilization equipment matches the nameplate voltage of that equipment as closely as possible.

N. Test all circuits, which under any circumstances can be paralleled, for proper phasing using hot phasing.

O. Acceptance: Observation of the operation of the electrical installation and equipment by the Project Architect/Engineer does not constitute acceptance of the Work. Acceptance will be made after the Contractor has adjusted his equipment, demonstrated that it meets the requirements of the Contract Document, and has furnished all the required certificates.

3.10 TOOLS AND SPARE PARTS

A. Use only tools designed for each operation. Keep tools in good condition. Do not use worn or broken tools. Wrench and vise teeth shall be sharp and clean to prevent damage to the materials. Screw drivers and wrenches shall be of the proper size to prevent damage to head or nuts.

B. Deliver special tools and spare parts provided with equipment to an authorized representative of the Owner. Obtain signed and dated receipts.

3.11 DEMONSTRATION

A. Demonstrate the essential features of the following mechanical and electrical systems upon completion of satisfactory testing:

1. Power System.

2. Lighting System.

3. Fire Alarm System.

4. Sound System.
5. Security System.

6. Emergency Generator.

B. Hold the demonstrations in the presence of the Owner or his designated representatives and the Project Architect/Engineer to show functions, locations and relationships to the Drawings. Demonstrate how to "start-stop", reset, replace, and emergency procedures. Demonstrate one system at a time.

3.12 EXISTING CONDITIONS

A. All work herein described and shown on drawings and required to make project complete in every respect, plus any and all patching necessary shall be done to the complete satisfaction of the Project Architect/Engineer and shall be accomplished in strict accordance with the drawings and technical specifications. All materials shall match existing where applicable and all construction and alteration left in new condition.

B. All items to be removed shall be removed with utmost care and without damage, and those items not designated to be reused shall be delivered to the Owner or disposed of as per his written instructions.

C. All alterations, demolition, and removal, cutting and patching and other work necessary for construction of this contract shall be performed without additional cost to the Owner. This shall include removal, rerouting, etc., of all electrical items required to complete installation intended.

D. Patch or replace all damaged floor, wall, ceiling, etc. surfaces altered to accommodate the new construction. Patched surfaces shall match existing adjacent surfaces.

E. All cutting, patching, demolition, repairing, replacing etc., necessary under this Contract shall be coordinated by the General Contractor. Where applicable, coordinate work with utility companies, local and state authorities having jurisdiction, Owner's representative and all applicable codes.

F. Where alterations take place in occupied areas, Contractor shall clean up daily, and noise shall be kept to a minimum.

G. None of the services to existing buildings shall be disrupted in any way except with the express permission of the Owner.

H. All equipment presently "hot" and required to be maintained shall be returned to this condition after performing the changes to existing building. Reroute conduits and extend or replace circuits as required. Perform work at convenience of the Owner.

I. Execute all work in such a manner and to avoid interference with the use of passage to and from adjoining buildings or areas.

J. The Contractor shall be fully responsible for any damage to existing building and to contents thereof including machinery, furniture, equipment, etc., and damage to buildings or contents thereof due to Contractor operations shall be repaired or replaced at direction of Project Architect/Engineer, by the Contractor, at no extra cost to the Owner.

K. Connection to existing structures shall be made in such a manner that as little time as absolutely possible will be taken, and Contractor will be required to coordinate fully with Owner in connection with convenience and safety of all persons involved, including employees.

L. Prior to commencement of work, verify measurements of building site. Submit discrepancies and differences to Architect/Engineer for consideration and decision before proceeding.

M. Obtain full information regarding peculiarities and limitations of space available for installation of all materials under contract. No extras will be allowed for any rework due to failure to bring this to the engineer's attention prior to rough-in.

END OF SECTION 260010

SECTION 260023

CODES AND STANDARDS

PART 1 GENERAL

1.01 REFERENCES

A. Comply with the latest edition, unless otherwise specifically noted, all or portions of the following codes and requirements:

1. The Florida Building Code (FBC)
2. The Standard Building Code, (SBC)
3. National Electric Code, (NEC)
4. NFPA, Life Safety Code and all other related NFPA codes
5. ANSI A117.1
6. ANSI A58.1 Wind Load Provisions

B. In addition to the foregoing the following shall apply:

1. Where materials and equipment are available under the continuing inspection and listing service of Underwriter's Laboratories, Inc., furnish materials and equipment so listed.

2. It is the contractors responsibility to be fully cognizant with all code sections as they apply to the work/installation at hand whether or not shown on the drawings but required by code. If any discrepancy arises between any design issues and code requirements, contractor must adhere to the most stringent approach.

PART 2 PRODUCTS NOT USED

PART 3 EXECUTION NOT USED

END OF SECTION 260023

SECTION 260523

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Low-voltage control cabling.
   2. Control-circuit conductors.
   3. Identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

2.2 PERFORMANCE REQUIREMENTS

A. 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.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat grey latex paint. Comply with requirements in Section 099123 "Interior Painting."

2.4 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One Multi-pair, twisted, No. 16 AWG, stranded (19x29) No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.5 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2 in raceway, complying with UL 83.

B. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway Type TW or Type TF, in raceway, complying with UL 83.

D. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

2.6 SOURCE QUALITY CONTROL

A. Factory test UTP cables according to TIA-568-C.2.

B. Factory test optical-fiber cables according to TIA-568-C.3.

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

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

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. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B 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 and NFPA 70.

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" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
4. Cables may not be spliced.
5. 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.
6. 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" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lie on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

3.4 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.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.6 GROUNDING

A. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 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-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

END OF SECTION 260523

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ERICO

B. BURNDY

C. O.Z./GEDNEY

2.2 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.

2.3 CONDUCTORS

A. 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.

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. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

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

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

2.5 GROUNDING ELECTRODES

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

PART 3 - EXECUTION

3.1 APPLICATIONS

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

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Conductor Terminations and Connections:

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

3.2 GROUNDING AT THE SERVICE

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

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.4 EQUIPMENT GROUNDING

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

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

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

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

3.5 INSTALLATION

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

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches 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. For grounding electrode system, install at least 2 rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

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

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

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

END OF SECTION 260526

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 ACTION SUBMITTALS

A. Product Data: For steel slotted support systems.

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron 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 non-armored 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 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, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type 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.

2.2 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 NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slottedsupport 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 single-bolt conduit clamps single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

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

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

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

   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 Spring-tension clamps.
   6. To Light Steel: Sheet metal screws.

7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

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

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

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

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

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

3.4 CONCRETE BASES

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

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

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. Touchup: Comply with requirements in Section 099000 “Painting and Coating” and Section 099610 “High Performance Coatings for Steel” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. IMC: Comply with ANSI C80.6 and UL 1242.

D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; aluminum.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:

a. Material: die cast.
b. Type: compression.

2. 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.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

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

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ENT: Comply with NEMA TC 13 and UL 1653.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. LFNC: Comply with UL 1660.

E. Continuous HDPE: Comply with UL 651B.

F. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

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

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

I. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

J. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R Type 4 Type 12 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.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

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

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

2.6 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,, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Metal Floor Boxes:

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

F. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

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

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

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

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum galvanized, cast iron with gasketed cover.

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

K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

L. Gangable boxes are allowed.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 Type 3R Type 4 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: Fiberglass.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets:

1. NEMA 250, Type 1 Type 3R 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.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

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

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

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with open 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.".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete reinforced concrete cast iron hot-dip galvanized-steel diamond plate fiberglass.

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with open 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.".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

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

1. Exposed Conduit: GRC IMC RNC, Type EPC-40-PVC RNC, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: GRC IMC EMT RNC, Type EPC-40-PVC.
3. Underground Conduit: RNC, Type EPC-40-PVC Type EPC-80-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

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

1. Exposed, Not Subject to Physical Damage: EMT ENT or RNC.
2. Exposed, Not Subject to Severe Physical Damage: EMT RNC identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC IMC. Raceway locations include the following:
   a. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT ENT or RNC, Type EPC-40-PVC.
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 nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 1/2-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, steel cast-metal fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

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

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. 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.

B. 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.

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

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

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

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

G. Raceways Embedded in Slabs:

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

5. Change from ENT to RNC, Type EPC-40-PVC, GRC or IMC before rising above floor.

H. 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.

I. 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.

J. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

L. 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.

M. 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.

N. Surface Raceways:

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

O. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.

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

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

Q. 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.
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 degree F of temperature change for PVC 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.

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

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

S. 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 bottom of box unless otherwise indicated.

T. 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 the box and cover plate or the supported equipment and box.

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

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

W. 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.

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

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

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

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

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

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches 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.

6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

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

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

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

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 260533

SECTION 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.
4. Manholes.

1.3 DEFINITIONS

A. Traffic ways: 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 separators and miscellaneous components.
2. Include ducts and 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 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 frame support rings.
e. Include Ladder Step 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. 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 C 858.

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 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 E 329 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.

B. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

A. Comply with ANSI C2.

2.2 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

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

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

   a. Color: Red dye added to concrete during batching.
   b. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Manufacturers: Subject to compliance with requirements,

1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast Group.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile Inc.
9. Brooks

B. Comply with ASTM C 858 for design and manufacturing processes.

C. 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.

1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

   a. Cover Hinges: Concealed, with hold-open ratchet assembly.
   b. Cover Handle: Recessed.

4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

    a. Cover Hinges: Concealed, with hold-open ratchet assembly.
    b. Cover Handle: Recessed.

5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, **"ELECTRIC."**
7. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
8. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches.
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

9. 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.
10. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

    a. Windows 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.
    b. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
    c. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

11. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

    a. Type and size shall match fittings to duct or conduit to be terminated.
    b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

    1. Color: Gray.

2. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, As indicated for each service.
6. 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.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

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

1. Manufacturers: Subject to compliance with requirements,:

a. Armorcast Products Company.
b. Carson Industries LLC.
c. NewBasis.
d. Quazite: Hubbell Power System, Inc.
e. Brooks

C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Manufacturers: Subject to compliance with requirements,:

a. Armorcast Products Company.
b. Carson Industries LLC.
c. Christy Concrete Products.
d. Quazite: Hubbell Power System, Inc.
e. Synertech Moulded Products, Inc.
f. Brooks

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers made of fiberglass.

1. Manufacturers: Subject to compliance with requirements,:

a. Carson Industries LLC.
b. Christy Concrete Products.
c. Nordic Fiberglass, Inc.
d. Quazite: Hubbell Power System, Inc.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of ducts, 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 ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts 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 according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths Walks and Driveways Roadways and Railroads: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. 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."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

3.4 DUCT INSTALLATION

A. Install ducts according to NEMA TCB 2.

B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.

C. 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.

D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the 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 bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, 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 line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit 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 banks with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit 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 duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

I. Pulling Cord: Install 100-lbf-test nylon cord in empty ducts.

J. Concrete-Encased Ducts: Support ducts on duct separators.

1. Excavate trench bottom to provide firm and uniform support for duct bank. 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 bank on each side.
3. Width: Excavate trench 3 inches wider than duct bank on each side.
4. Depth: Install top of duct bank 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 ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
6. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than [**four**] [**five**] spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. 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 Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
8. Elbows: Use manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Extend concrete encasement throughout length of elbow.
9. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Reinforcement: Reinforce concrete-encased duct banks 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 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 at top and bottom, and a minimum of 2 inches on each side of duct bank.
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 ducts as their temperature changes during and after the pour. Use expansion fittings installed according to 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 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 conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. 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.

K. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than [**four**] [**five**] spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

9. After installing first tier of ducts, 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 ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.

L. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of 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.

M. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. 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. Windows 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 C 891 unless otherwise indicated.

2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, 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. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. 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. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

G. 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 ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, 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 removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

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

F. 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, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

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 and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts 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 6-inch-long mandrel equal to 80 percent fill of duct. 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.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

SECTION 260544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 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 078400 "Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

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

C. 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. Sealing Elements: **EPDM, Nitrile (Buna N)**] rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: [**Carbon steel**] [**Plastic**] [**Stainless steel**].
3. Connecting Bolts and Nuts: [**Carbon steel, with corrosion-resistant coating,**] [**Stainless steel**] of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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

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.
2. Sealant shall have VOC content of 250g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking 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 079005 "Joint Sealers."
   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.

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 4” 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**] [**cast-iron**] pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

END OF SECTION 260544

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

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

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

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

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage 120/208V 3 PH.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

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

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

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

D. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

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

B. Color and Printing:

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

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 4 mils.
3. Weight: 18.5 lb/1000 sq. ft..
4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, 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.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; 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.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements including compliance with VOC limits for all paints and coatings to be applied inside the building envelope. Select 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 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

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

C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

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

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line 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.

G. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. 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: Install labels at 30-foot maximum intervals.

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

1. Emergency Power.
2. Power.
3. UPS.

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

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

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

        1) Phase A: Black.
        2) Phase B: Red.
        3) Phase C: Blue.

    c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

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

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

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

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

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

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.

4. 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.

I. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Adhesive film label with clear protective overlay Self-adhesive, engraved, laminated acrylic or melamine label Engraved, laminated acrylic or melamine label. 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.
    b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
    c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 260553

SECTION 260943

NETWORK LIGHTING CONTROLS

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

A. Section 12 2400 - Window Shades: Motorized roller window shades, for interface with lighting control system.

B. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

C. Section 26 7726 - Wiring Devices:

D. Section 26 5113 – "Incandescent Interior Lighting".

E. Section 26 5116 –"Fluorescent Interior Lighting".

F. Section 265119 – "LED Interior Lighting".

1.02 REFERENCE STANDARDS

A. ANSI C82.11 - American National Standard for Lamp Ballasts - High Frequency Fluorescent Lamp Ballasts - Supplements; 2011.

B. ANSI/ESD S20.20 - Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices); 2007.

C. ASTM D4674 - Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments; 2002a (Reapproved 2010).

D. IEC 60929 - AC and/or DC-Supplied Electronic Control Gear for Tubular Fluorescent Lamps - Performance Requirements; 2011.

E. IEC 61000-4-2 - Electromagnetic Compatibility (EMC) - Part 4-2: Testing and Measurement Techniques - Electrostatic Discharge Immunity Test; 2008.

F. IEC 61000-4-5 - Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test; 2008.

G. IEC 61347-2-3 - Lamp Control Gear - Part 2-3: Particular Requirements for A.C. and/or D.C. Supplied Electronic Control Gear for Fluorescent Lamps; 2011.

H. IEC 61347-2-13 - Lamp Control Gear - Part 2-13: Particular Requirements for D.C. or A.C. Supplied Electronic Control Gear for LED Modules; 2006.

I. IEEE C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; 2002 (Cor 1, 2012).

J. ISO 9001 - Quality Management Systems-Requirements; 2008.

K. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2010.

L. NECA 130 - Standard for Installing and Maintaining Wiring Devices; National Electrical Contractors Association; 2010.

M. NEMA WD 1 - General Color Requirements for Wiring Devices; National Electrical Manufacturers Association; 1999 (R 2005).

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

O. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

P. UL 924 - Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.

Q. UL 935 - Fluorescent-Lamp Ballasts; Current Edition, Including All Revisions.

R. UL 1472 - Solid-State Dimming Controls; Current Edition, Including All Revisions.

S. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; Current Edition, Including All Revisions.

T. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the placement of sensors and wall controls with millwork, furniture, equipment, etc. installed under other sections or by others.
   2. Coordinate the placement of wall controls with actual installed door swings.
   3. Coordinate the placement of daylight sensors with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
   4. Where motorized window treatments are to be controlled by the lighting control system provided under this section, coordinate the work with other trades to provide compatible products.
   5. Coordinate the work to provide luminaires and lamps compatible with the lighting controls to be installed.
   6. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

B. Pre-installation Meeting: Conduct on-site meeting with lighting control system manufacturer prior to commencing work as part of manufacturer's standard startup services. Manufacturer to review with installer:
   1. Low voltage wiring requirements.
   2. Separation of power and low voltage/data wiring.
   3. Wire labeling.
   4. Lighting management hub locations and installation.
   5. Control locations.

6. Computer jack locations.
7. Load circuit wiring.
8. Network wiring requirements.
9. Connections to other equipment and other equipment.
10. Installer responsibilities.
11. Power panel locations.

C. Sequencing:
1. Do not install sensors and wall controls until final surface finishes and painting are complete.

1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements for submittal procedures.

B. Design Documents: Lighting control manufacturer to provide plans indicating occupancy/vacancy and/or daylight sensor locations as part of sensor layout and tuning services specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS".

C. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
1. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams.

D. Shop Drawings:
1. Provide schematic system riser diagram indicating component interconnections. Include requirements for interface with other systems.
2. Provide detailed sequence of operations describing system functions.

E. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

F. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

G. Software: One copy of software provided under this section.

1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications:
1. Company with not less than ten years of experience manufacturing lighting control systems of similar complexity to specified system.
2. Registered to ISO 9001, including in-house engineering for product design activities.

3. Qualified to supply specified products and to honor claims against product presented in accordance with warranty.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.07 FIELD CONDITIONS

A. Maintain field conditions within manufacturer's required service conditions during and after installation.
   1. System Requirements Lighting Controls manufacturer, Unless Otherwise Indicated:
      a. Ambient Temperature:
         1) Lighting Control System Components, Except Those Listed Below: Between 32 and 104 degrees F (0 and 40 degrees C).
         2) Lighting Management System Computer: Between 50 and 90 degrees F (10 and 35 degrees C).
         3) Fluorescent Electronic Dimming Ballasts: Between 50 and 140 degrees F (10 and 60 degrees C).
      b. Relative Humidity: Less than 90 percent, non-condensing.

1.08 WARRANTY

A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

B. Manufacturer's Standard Warranty, With Manufacturer Start-Up; Standard 2-Year Warranty:
   1. Lighting Control System Components, Except Lighting Management System Computer, Ballasts and Ballast Modules:
      a. First Two Years:
         1) 100 percent replacement parts coverage, 100 percent manufacturer labor coverage to troubleshoot and diagnose a lighting issue.
         2) First-available on-site or remote response time.
      b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.
   2. Lighting Management System Computer: One year 100 percent parts coverage, one year 100 percent manufacturer labor coverage.
   3. Ballasts and Ballast Modules: Five years 100 percent parts coverage, no manufacturer labor coverage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design Manufacturer: Lutron Electronics Company, Inc; www.lutron.com.

B. Substitutions: See Section 01 6000 - Product Requirements.
   1. By using pre-approved substitutions, Contractor accepts responsibility and associated costs for all required modifications to related equipment and wiring. Provide complete engineered shop drawings (including power wiring) with deviations from the original design highlighted in an alternate color for review and approval by Architect prior to rough-in.

2.02 DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS

A. Include as part of the base bid additional costs for manufacturer's sensor layout and tuning services; LSC-SENS-LT:
   1. Lighting control manufacturer to design occupancy/vacancy and/or daylight sensor layout (wired and/or wireless sensors) that provides adequate coverage and performs according to required sequence of operations.
   2. Lighting control manufacturer to visit site for preinstallation meeting and system startup; lighting control manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
   3. Any additional sensors or hardware required to meet sequence of operations to be furnished by lighting control manufacturer at no additional cost.
   4. Lighting control manufacturer to provide up to two additional post-startup on-site service visits for fine-tuning of sensor calibration.

B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.

C. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the control intent indicated.

D. Shade Control Requirements:
   1. Capable of operating shades independently, without use of external group controllers.
   2. Capable of controlling shade speed for tracking within plus or minus 0.125 inch (3.17 mm) throughout entire travel.
   3. Provide 10 year power failure memory for preset stops, open and close limits, shade grouping and sub grouping and system configuration.
   4. Capable of synchronizing multiple shade electronic drive units of the same size to start, stop and move in unison.
   5. Capable of controlling any shade electronic drive unit via keypads and contact closure inputs without separate group controller.
   6. Capable of operating any group or sub group of shade electronic drive units within subsystem via keypads and interfaces.
   7. Capable of one-touch control of shades via keypad, lighting control, or handheld remote.
   8. Capable of stopping shades within accuracy of 0.125 inch (3.17 mm) at any point between open and close limits.

9. Capable of storing up to 250 programmable stop points, including open, close, and any other position.
10. Capable of recalling presets via keypad, contact closure input, infrared receiver, lighting management system software, or other lighting control system interface.
11. Capable of controlling lights and shades from single wall control button.

E. Design lighting control equipment for 10 year operational life while operating continually at any temperature in an ambient temperature range of 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) and 90 percent non-condensing relative humidity.

F. Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.

G. Dimming and Switching (Relay) Equipment:
1. Designed so that electrolytic capacitors operate at least 36 degrees F (20 degrees C) below the capacitor's maximum temperature rating when the device is under fully loaded conditions at maximum rated temperature.
2. Inrush Tolerance:
   a. Utilize load-handling thyristors (SCRs and triacs), field effect transistors (FETs) and isolated gate bipolar transistors (IGBTs) with maximum current rating at least two times the rated operating current of the dimmer/relay.
   b. Capable of withstanding repetitive inrush current of 50 times the operating current without impacting lifetime of the dimmer/relay.
3. Surge Tolerance:
   a. Panels: Designed and tested to withstand surges of 6,000 V, 3,000 amps according to IEEE C62.41.2 and IEC 61000-4-5 without impairment to performance.
   b. Other Power Handling Devices: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
4. Power Failure Recovery: When power is interrupted and subsequently restored, within 3 seconds lights to automatically return to same levels (dimmed setting, full on, or full off) as prior to power interruption.
5. Dimming Requirements:
   a. Line Noise Tolerance: Provide real-time cycle-by-cycle compensation for incoming line voltage variations including changes in RMS voltage (plus or minus 2 percent change in RMS voltage per cycle), frequency shifts (plus or minus 2 Hz change in frequency per second), dynamic harmonics, and line noise.
      1) Systems not providing integral cycle-by-cycle compensation to include external power conditioning equipment as part of dimming system.
   b. Incorporate electronic "soft-start" default at initial turn-on that smoothly ramps lights up to the appropriate levels within 0.5 seconds.
   c. Utilize air gap off to disconnect the load from line supply.
   d. Control all light sources in smooth and continuous manner. Dimmers with visible steps are not acceptable.

e. Load Types:
   1) Assign a load type to each dimmer that will provide a proper dimming curve for the specific light source to be controlled.
   2) Provide capability of being field-configured to have load types assigned per circuit.
f. Minimum and Maximum Light Levels: User adjustable on a circuit-by-circuit basis.
g. Line Voltage Dimmers:
   1) Dimmers for Magnetic Low Voltage (MLV) Transformers:
      (a) Provide circuitry designed to control and provide a symmetrical AC waveform to input of magnetic low voltage transformers per UL 1472.
      (b) Dimmers using unipolar load current devices (such as FETs or SCRs) to include DC current protection in the event of a single device failure.
   2) Dimmers for Electronic Low Voltage (ELV) Transformers: Operate transformers via reverse phase control. Alternately, forward phase control dimming may be used if dimming equipment manufacturer has recommended specific ELV transformers being provided.
   3) Dimmers for Neon and Cold Cathode Transformers:
      (a) Magnetic Transformers: Listed for use with normal (low) power factor magnetic transformers.
      (b) Electronic Transformers: Must be supported by the ballast equipment manufacturer for control of specific ballasts being provided.
h. Low Voltage Dimming Modules:
   1) Coordination Between Low Voltage Dimming Module and Line Voltage Relay: Capable of being electronically linked to a single zone.
   2) Single low voltage dimming module; capable of controlling the following light sources:
      (a) 0-10V analog voltage signal.
         (1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
         (2) Sink current according to IEC 60929.
         (3) Source current.
      (b) 10-0V reverse analog voltage signal.
      (c) DSI digital communication.
      (d) DALI broadcast communication per IEC 60929:
         (1) Logarithmic intensity values complying with IEC 60929.
         (2) Linear intensity values for use with LED color intensity control.
      (e) PWM per IEC 60929.

6. Switching Requirements:
   a. Rated Life of Relays: Minimum of 1,000,000 cycles at fully rated current for all lighting loads.
   b. Switch load in a manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.

c. Provide output fully rated for continuous duty for inductive, capacitive, and resistive loads.

H. Device Finishes:
1. Standard Colors: Comply with NEMA WD1 where applicable.
2. Color Variation in Same Product Family: Maximum delta E of 1, CIE L*a*b color units.
3. Visible Parts: Exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674. Provide proof of testing upon request.

2.03 FLUORESCENT ELECTRONIC DIMMING BALLASTS

A. General Requirements:
1. Designed for 10 year operational life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
2. Designed and tested to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
3. Lamp Starting Method: Programmed rapid start.
4. Maximum Inrush Current: 7 amperes for 120V ballasts and 3 amperes for 277V ballasts.
5. Current Crest Factor (CCF): Less than 1.7.
6. Comply with ANSI C82.11 and list and label as complying with UL 935.
7. Designed to not interfere with infrared devices operating at frequencies between 38 kHz and 42 kHz.
8. Manufactured in a facility that employs ESD reduction practices in compliance with ANSI/ESD S20.20.
9. Inaudible in a 27 dBA ambient.
10. No visible change in light output with a variation of plus or minus 10 percent line voltage input.
11. Actively prevent overheating in T5-HO linear fluorescent lamp applications.
12. Ballasts to track evenly across multiple lamp lengths and all light levels.
13. Comply with IEC 61347-2-3 as applicable.

B. Digital Control:
1. Monitor and report lamp and ballast status.
2. Lights automatically return to the setting prior to power interruption.
3. Each ballast responds independently to:
   a. Up to 32 occupant sensors.
   b. Up to 64 personal control inputs.
   c. Two daylight sensors.
4. Unique internal reference number visibly displayed on ballast cover.
5. Averages two independent daylight harvesting inputs internally.
6. Responds to digital load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast automatically sets the maximum light output at 90 percent and lowers current light output by three percent to 27 percent).

C. Product(s):

1. 3-Wire and Digital Control, Ten Percent Dimming; EcoSystem:
    a. Dimming Range: 100 to ten percent relative light output for T8, T5, T5HO, and T5 twin-tube, and five percent relative light output for T4 compact lamps.
    b. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C41.2 without impairment of performance.
    c. Total Harmonic Distortion (THD): Less than 15 percent.
    d. Digital Control:
        1) Connect without interface (except for T4 compact lamp ballasts) to:
            (a) Occupancy sensors.
            (b) Daylight sensor.
            (c) Personal control input (keypad or infrared receiver).
        2) Provide a 20V DC source to power connected sensors.
        3) Generate digital communication commands to distribute ballast and sensor data on the digital bus.
2. Digital Control, One Percent Dimming; EcoSystem H-Series:
    a. Dimming Range: 100 to less than one percent relative light output for T8, and one percent relative light output for T5 and T5HO lamps.
    b. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C41.2 without impairment of performance.
    c. Total Harmonic Distortion (THD): Less than 10 percent.

2.04 LED DRIVERS

A. Product: DALI Digitally controlled A-Series drivers

B. General Requirements:
1. Designed for 10 year operational life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
2. Designed and tested to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
3. Maximum Inrush Current: 2 amperes for 120V and 277V drivers.
4. UL 8750 recognized or listed as applicable.
5. Comply with IEC 61347-2-13 as applicable.
6. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C62.41.2 without impairment of performance.
7. Manufactured in a facility that employs ESD reduction practices in compliance with ANSI/ESD S20.20.
8. Class A sound rating; Inaudible in a 27 dBA ambient.
9. No visible change in light output with a variation of plus or minus 10 percent line voltage input.
10. Total Harmonic Distortion (THD): Less than 20 percent; comply with ANSI C82.11.
11. Drivers to track evenly across multiple lamp lengths and all light levels.
12. Constant Current Drivers:
    a. Support from 200 mA to 2.1 A (in 10 mA steps) to ensure a compatible driver exists.

b. Support LED arrays up to 40W or 50 W (710 mA to 1.05 A in 10 mA steps).

13. Constant Voltage Drivers:
    a. Support from 10 V to 40 V (in 0.5 V steps) to ensure a compatible driver exists.
    b. Support LED arrays up to 40W.
14. Configuration tool available to optimize the following for LED fixtures:
    a. Light level.
    b. Efficacy.
    c. Thermal performance.

C. Digital Control:
1. Dimming Range: 100 to one percent relative light output.
2. Lights automatically return to the setting prior to power interruption.
3. Operate from input voltage of 120 V through 277 V at 60 Hz.
4. Each driver responds independently to:
    a. Up to 32 occupant sensors.
    b. Up to 16 daylight sensors.
5. Responds to digital load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast automatically sets the maximum light output at 90 percent and lowers current light output by three percent to 27 percent).

2.05 POWER INTERFACES

A. Provide power interfaces as indicated or as required to control the loads as indicated.

B. General Requirements:
1. Phase independent of control input.
2. Rated for use in air-handling spaces as defined in UL 2043.
3. Utilize air gap off to disconnect the load from line supply.
4. Diagnostics and Service: Replacing power interface does not require re-programming of system or processor.

2.06 LIGHTING CONTROL MODULES (ENERGI SAVR NODE)

A. Provide lighting control modules as indicated or as required to control the loads as indicated.

B. General Requirements:
1. Listed to UL 508 as industrial control equipment.
2. Delivered and installed as a listed factory-assembled panel.
3. Passively cooled via free-convection, unaided by fans or other means.
4. Mounting: Surface.
5. Connection without interface to wired:
    a. Occupancy sensors.
    b. Daylight sensors.
    c. IR receivers for personal control.
6. Connects to lighting management hub via RS485.

7. LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
8. Contact Closure Input:
    a. Directly accept contact closure input from a dry contact closure or sold-state output without interface to:
        1) Activate scenes.
            (a) Scene activation from momentary or maintained closure.
        2) Enable or disable after hours.
            (a) Automatic sweep to user-specified level after user-specified time has elapsed.
            (b) System will provide occupants a visual warning prior to sweeping lights to user-specified level.
            (c) Occupant can reset timeout by interacting with the lighting system.
        3) Activate or deactivate demand response (load shed).
            (a) Load shed event will reduce lighting load by user-specified amount.
9. Emergency Contact Closure Input:
    a. Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
    b. Allow configurable zone response during emergency state.
    c. Disable control operation until emergency signal is cleared.
10. Supplies power for control link for keypads and control interfaces.
11. Distributes sensor data among multiple lighting control modules.
12. Capable of being controlled via wireless sensors and controls.

C. Switching Lighting Control Modules:
    1. Product: SoftSwitch Energi Savr Node; Model QSN-4S16-S.
    2. Switching:
        a. Rated Life of Relay: Minimum of 1,000,000 cycles at fully rated current for all lighting loads.
        b. Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
        c. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
        d. Module to integrate up to four individually controlled zones, each with a capacity of up to 16 amps of high in-rush lighting load (magnetic fluorescent ballast, electronic fluorescent ballast, incandescent, magnetic low-voltage, electronic low-voltage, neon/cold cathode and motor loads).
        e. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.

D. Digital Fixture Lighting Control Modules:
    1. Product(s):
        a. EcoSystem Energi Savr Node; Model QSN-1ECO-S: One EcoSystem Digital Link.

b. EcoSystem Energi Savr Node; Model QSN-2ECO-S: Two EcoSystem Digital Links.

2. Provide smart diagnostics for system verification.
3. Provide testing capability using manual override buttons.
4. Each low-voltage digital communication link to support up to 64 ballasts or LED drivers capable of NFPA 70 Class 1 or Class 2 installation.

2.07 DIGITAL DIMMING BALLAST AND SWITCHING MODULES (ECOSYSTEM)

A. Provide digital dimming ballast and switching modules as indicated or as required to control the loads as indicated.

B. General Requirements:
   1. Provide continuous 3-wire signal dimming to compatible 3-wire electronic dimming ballasts.
   2. Utilize air gap off to disconnect the load from line supply.
   3. Connect without interface to:
      a. Occupancy sensor.
      b. Daylight sensor.
      c. Personal control input (wall station or infrared receiver).
   4. Generate digital communication commands to distribute ballast and sensor data on the digital bus.
   5. If power is interrupted and subsequently restored, lights automatically return to the setting prior to power interruption.
   6. Each ballast module responds independently to:
      a. Up to 32 occupancy sensors.
      b. Up to 64 personal control inputs.
      c. Two daylight sensors.
   7. Unique internal reference number visible displayed on module cover.
   8. Averages two independent daylight harvesting inputs internally.
   9. Responds to digital load shed command.
      a. Sets high end trim.
      b. Automatically scales light output proportional to load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast to automatically set the maximum light output at 90 percent and lower current light output by 3 percent to 27 percent).
   10. Provide integral fault protection to prevent ballast module failure in the event of a mis-wire.

2.08 LIGHTING MANAGEMENT HUBS

A. Product: Quantum Light Management Hub.

B. Provided in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.

C. Connects to controls and power panels via RS485.

D. Enables light management software to control and monitor compatible dimming ballasts and ballast modules, power panels, power modules, and window treatments.
   1. Utilizes Ethernet connectivity to light management computer utilizing one of the following methods:
      a. Dedicated network.
      b. Dedicated VLAN.
      c. Shared network with Building Management System (BMS).
      d. Corporate network where managed switches are configured to allow multicasting and use of IGMP.

E. Integrates control station devices, power panels, shades, preset lighting controls, and external inputs into a single customizable lighting control system with:
   1. Multiple Failsafe Mechanisms:
      a. Power failure detection via emergency lighting interface.
      b. Protection: Lights go to full on if ballast wires are shorted.
      c. Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights and shades connected to other lighting management hubs.
   2. Manual overrides.
   3. Automatic control.
   4. Central computer control and monitoring.

F. Furnished with astronomical time clock.

G. Furnished with solar clock to track the position of the sun to control the shades to limit penetration of direct sunlight.

H. Maintains a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.

2.09 LIGHTING MANAGEMENT SYSTEM COMPUTERS

A. Computers:
   1. Product: Q-Manager.
   2. System PC (Desktop/Laptop):
      a. Suitable for occasional programming, monitoring, and control of digital network lighting controls.
      b. Unless otherwise indicated, computer(s) to be provided by lighting control system manufacturer.
      c. Minimum Hardware Requirements:
         1) Processor: Single Intel® Xeon® processor with minimum speed of 2.0 GHz.
         2) 1 GB RAM.
         3) 80 GB hard drive (30 GB for application).
         4) One 10/100/1000 Ethernet network interface for communication with lighting management hubs.
         5) 17 inch (43 cm) monitor with 1024 x 768 resolution.
         6) 48X CD/DVD-ROM drive.

7) 4 USB 2.0 ports.

d. Minimum Software Requirements:

1) Licensed installation of US English 32-bit or 64-bit Microsoft® Windows® Server 2008 with Service Pack 1.

3. Computers Provided by Lighting Control System Manufacturer: Computer software to be preinstalled and tested prior to shipping.

2.10 LIGHTING MANAGEMENT SYSTEM SOFTWARE

A. Provide system software license and hardware that is designed, tested, manufactured, and warranted by a single manufacturer.

B. Configuration Setup Software:

1. Product: Q-Design.
2. Suitable to make system programming and configuration changes.
3. Windows-based, capable of running on either central server or a remote client over TCP/IP connection.
4. Allows manufacturer (either remotely or with on-site service call) or end-user (with training) to:

a. Capture system design:

1) Geographical layout.
2) Load schedule zoning.
3) Shade grouping.
4) Equipment schedule.
5) Equipment assignment to lighting management hubs.
6) Daylighting design.

b. Define the configuration for the following in each area:

1) Lighting scenes.
2) Shade group presets.
3) Control station devices.
4) Interface and integration equipment.
5) Occupancy/after hours.
6) Partitioning.
7) Daylighting.
8) Emergency lighting.
9) Night lights.

c. Startup:

1) Addressing.
2) Daylighting.
3) Provide customized conditional programming.

C. Control and Monitor Software:

1. Product: Q-Admin.
2. Basic System View: The system navigation and status reporting is performed using a tree view of the building.
3. Control of Lights:

a. Area lights can be monitored for on/off status.

b. All lights in an area can be turned on/off or sent to a specific level.
c. For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
d. Area lighting scenes can be modified in real-time, changing the levels that zones go to when a scene is activated.
e. High and low end of area lighting can be tuned/trimmed.
f. Control and monitor area partition status.

4. Control of Shades:
   a. Area shades can be monitored for current preset or position.
   b. Area shades can be opened/closed, sent to a preset, or sent to a specific position.
5. Occupancy:
   a. Area occupancy can be monitored.
   b. Area occupancy can be disabled to override occupancy control or in case of occupancy sensor problems.
   c. Area occupancy settings including level that lights turn on to when area is occupied, and level that lights turn off to when area is unoccupied can be changed in real-time.
6. Daylighting:
   a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
   b. Daylight target levels can be changed for each daylit area.
   c. Daylight status can be monitored.
7. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
8. Reporting: Provide reporting capability that allows the building manager to gather real-time and historical information about the system as follows:
   a. Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas or meter groups.
   b. Power Reports: Show power usage trend over a period of time for one or more areas or meter groups.
   c. Activity Report: Show what activity has taken place over a period of time for one or more areas. Activity includes occupant activities (e.g. wall controls being pressed), building manager operation (e.g. controlling/changing areas using the control and monitor tool), and device failures (e.g. keypads or ballasts that are not responding).
      1) Include shade related activities (e.g. automatic movements from Hyperion algorithm, manual overrides from personal controls, automatic overrides from sensors).
   d. Lamp Failure Report: Shows which areas are currently reporting lamp failures.
   e. Shade Level Report: Shows the shade level for any shade group in the system over any historical 24 hour period.
   f. Shade Position Report: Shows the percentage of time shade groups in the system are at each position.

g. Sensor Level Report: Shows the light level in footcandles of any photosensor in the system.
h. Alert Activity Report: Capable of generating historical reports of all alert activity within the system.

9. Diagnostics: Allows the building manager to check on the status of all equipment in the lighting control system. Devices to be listed with a reporting status of OK, missing, or unknown.
10. Alerts and Alarms: Monitors the system for designated events/triggers and automatically generates alerts according to configured response criteria.
    a. Capable of monitoring for the following events/triggers:
        1) A failed piece of equipment (e.g. ballast, control, sensor, etc.); alert cleared when equipment is replaced.
        2) A lamp outage (for compatible EcoSystem digital electronic dimming ballasts only); alert cleared when lamp is replaced.
        3) Low battery conditions in battery-operated sensors and controls; alert cleared when battery is replaced.
        4) Luminaires with lamp operating hours in excess of designated time.
        5) A load shed event; alert generated for beginning and end of trigger.
        6) Energy usage higher than designated threshold target.
        7) Potential light level condition discrepancies (daylight sensors not agreeing with expected lighting status).
    b. Capable of generating alerts through visible changes in software or through email messages.
    c. Capable of customizing the frequency of alerts and providing notifications immediately or through daily, weekly, or monthly summaries.
    d. Capable of sending different alerts to different system users.
    e. Capable of generating historical reports of all alert activity within the system.
11. Administration:
    a. Users: Allows new user accounts to be created and existing user accounts to be edited.
        1) Supports Active Directory (LDAP) tying user accounts to network accounts.
    b. Area and feature access can be restricted based on login credentials with three levels of access rights (Admin, Programmer, Controller) and customized access levels available.
    c. Publish Graphical Floor Plan: Allows admin user to publish new graphical floor plan files, allowing users to monitor the status of lights, occupancy of areas, and daylighting status.
    d. Back-Up Project Database: Allows admin user to back up the project database that holds all the configuration information for the system, including keypad programming, areas scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
    e. Publish Project Database: Allows admin user to send a new project database to the server and download the new configuration to the system. The project database holds all the configuration information for the system, including

keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.

12. Virtual Global Buttons: Provide global scene control or modes of operation across entire system.
13. Provides control/monitoring of partition status to automatically reconfigure how the space operates based on the partition's open/closed status.

2.11 CONTROL STATIONS

A. Provide control stations with configuration as indicated or as required to control the loads as indicated.

B. Wired Control Stations:
   1. General Requirements:
      a. Class 2 (low voltage).
      b. UL listed.
      c. Control stations can be replaced without reprogramming.
   2. Product(s):
      a. Multi-Scene Wired Control:
         1) Product(s):
         2) Allows control of any devices part of the lighting control system.
         3) Utilize RS485 wiring for low-voltage communication.
         4) Functionality:
            (a) Upon button press, LEDs to immediately illuminate.
            (b) LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or LEDs to turn off if the button press was not processed.
            (c) Allows for easy reprogramming without replacing unit.
            (d) Replacement of units does not require reprogramming.
         5) Provide faceplates with concealed mounting hardware.
         6) Engrave wall stations with button, zone, and scene descriptions as indicated on the drawings.
         7) Silk-screened borders, logos, and graduations to use graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.
         8) Software Configuration:
            (a) Customizable control station device button functionality:
               (1) Buttons can be programmed to perform single defined action.
               (2) Buttons can be programmed to perform defined action on press and defined action on release.
               (3) Buttons can be programmed using conditional logic off of a state variable such as time of day or partition status.
         9) Control station device LEDs to support logic that defines when it is illuminated:
            (a) Scene logic (logic is true when all zones are at defined levels).
            (b) Room logic (logic is true when at least one zone is on).

(c) Pathway (logic is true when at least one zone is on).
(d) Last scene (logic is true when spaces are in defined scenes).

10) Contact Closure Interface: Accepts both momentary and maintained contact closures.

C. Wireless (Radio Frequency) Controls:
1. Product: Pico Wireless Control.
2. Communicates via radio frequency to compatible dimmers, switches, and plug-in modules.
3. Does not require external power packs, power or communication wiring.
4. Allows for easy reprogramming without replacing unit.
5. Button Programming:
   a. Single action.
   b. Toggle action.
   c. Defined action on press and defined action on release.
6. Includes LED to indicate button press or programming mode status.
7. Models available with integral night light.
8. Mounting:
   a. Capable of being mounted with a table stand or directly to a wall under a faceplate.
   b. Faceplates: Provide concealed mounting hardware.
9. Power: Battery-operated with minimum ten-year battery life.

2.12 WIRELESS SENSORS

A. General Requirements:
1. Operational life of 10 years without the need to replace batteries when installed per manufacturer's instructions.
2. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.
3. Does not require external power packs, power wiring, or communication wiring.
4. Capable of being placed in test mode to verify correct operation from the face of the unit.
5. RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
6. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.

B. Wireless Occupancy/Vacancy Sensors:
1. General Requirements:
   a. Provides a clearly visible method of indication to verify that motion is being detected during testing and that the unit is communicating to compatible RF receiving devices.
   b. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
   c. Sensing Mechanism: Passive infrared coupled with technology for sensing fine motions. Signal processing technology detects fine-motion passive

infrared (PIR) signals without the need to change the sensor's sensitivity threshold.

d. Provide optional, readily accessible, user-adjustable controls for timeout, automatic/manual-on, and sensitivity.
e. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area. Provide adjustable timeout settings of 1, 5, 15, and 30 minutes.
f. Capable of turning dimmer's lighting load on to an optional locked preset level selectable by the user. Locked preset range to be selectable on the dimmer from 1 percent to 100 percent.
g. Color: White.
h. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
i. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.
j. Sensor lens to illuminate during test mode when motion is detected to allow installer to verify coverage prior to permanent mounting.
k. Ceiling-Mounted Sensors:
    1) Provide customizable mask to block off unwanted viewing areas.
l. Wall-Mounted Sensors: Provide wall or corner mounting brackets compatible with drywall and plaster walls.

2. Wireless Combination Occupancy/Vacancy Sensors:
    a. Ceiling-Mounted Sensors: Programmable to operate as an occupancy sensor (automatic-on and automatic-off), an occupancy sensor with low light feature (automatic-on when less than one footcandle of ambient light available and automatic-off), or a vacancy sensor (manual-on and automatic-off).
    b. Wall-Mounted Sensors: Programmable to operate as an occupancy sensor (automatic-on and automatic-off), or a vacancy sensor (manual-on and automatic-off).
    c. Product(s):
        1) Type Ceiling-Mounted Occupancy/Vacancy Sensor; Model LFR2-OCR2B-P-WH: Coverage from 324 square feet (30.2 sq m) to 676 square feet (62.4 sq m) depending on ceiling height from 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.
        2) Type Wall-Mounted Occupancy/Vacancy Sensor; Model LFR2-OWLB-P-WH: Minor motion coverage of 1500 square feet (139.4 sq m) and major motion coverage of 3000 square feet (278.7 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 180 degree field of view.
        3) Type Corner-Mounted Occupancy/Vacancy Sensor; Model LFR2-OKLB-P-WH: Minor motion coverage of 1225 square feet (113.8 sq m) and major motion coverage of 2500 square feet (232.3 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 90 degree field of view.

4) Type Hallway Occupancy/Vacancy Sensor; Model LFR2-OHLB-P-WH: Major motion coverage of up to 150 feet (45.7 m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); narrow field of view.

C. Wireless Daylight Sensors:
   1. Product: Model LFR2-DCRB.
   2. Open-loop basis for daylight sensor control scheme.
   3. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
   4. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
   5. Provide linear response from 0 to 10,000 footcandles.
   6. Color: White.
   7. Mounting:
      a. Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
      b. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
      c. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.

2.13 ACCESSORIES

A. Emergency Lighting Interface:
   1. Product: Model LUT-ELI.
   2. Provides total system listing to UL 924 when used with lighting control system.
   3. Senses all three phases of building power.
   4. Provides an output to power panels or digital ballast interfaces if power on any phase fails and sends all lights controlled by these devices to an emergency light level setting. Lights to return to their previous intensities when normal power is restored.
   5. Accepts a contact closure input from a fire alarm control panel.

B. Provide power supplies as indicated or as required to power system devices and accessories.

2.14 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Factory Testing _____:
   1. Perform full-function factory testing on all completed assemblies. Statistical sampling is not acceptable.
   2. Perform full-function factory testing on 100 percent of all ballasts and LED drivers.
   3. Perform factory audit burn-in of all dimming assemblies and panels at 104 degrees F (40 degrees C) at full load for two hours.

4. Perform factory burn-in of 100 percent of all ballasts at 104 degrees F (40 degrees C).

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as shown on the drawings.

B. Verify that ratings and configurations of system components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive system components.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, except for mounting heights specified in those standards.

B. Install products in accordance with manufacturer's instructions.

C. Provide dedicated network between lighting management system computer and lighting management hubs.

D. Define each dimmer/relay load type, assign each load to a zone, and set control functions.

E. Sensor Locations: Do not make adjustments to locations without obtaining approval from the Engineer.

F. Mount exterior daylight sensors to point due north with constant view of daylight.

G. Ensure that daylight sensor placement minimizes sensor view of electric light sources. Locate ceiling-mounted and luminaire-mounted daylight sensors to avoid direct view of luminaires.

H. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

I. Lamp Lead Lengths: Do not exceed 3 feet (0.9 m) for T4 4-pin compact and T5 BIAX lamps and 7 feet (2.1 m) for T5, T5-HO, T8 U-bend, and T8 linear fluorescent lamps.

J. LED Light Engine/Array Lead Length: Do not exceed 100 feet (31 m).

K. Identify system components in accordance with Section 26 0553.

3.03 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. See article "SYSTEM STARTUP" below for requirements related to testing and inspection.

C. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

3.04 SYSTEM STARTUP

A. Provide services of a manufacturer's certified service representative to perform system startup.

B. Manufacturer's Startup Services; Standard Startup Services:
   1. Manufacturer's certified service representative to conduct minimum of three site visits to ensure proper system installation and operation.
   2. Conduct first visit to review requirements with installer as specified in Part 1 under "Administrative Requirements".
   3. Conduct second site visit upon completion of lighting control system to perform system startup and verify proper operation:
      a. Verify sensor locations, in accordance with layout provided by lighting control manufacturer as part of sensor layout and tuning services specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS"; lighting control manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
      b. Verify connection of power wiring and load circuits.
      c. Verify connection and location of controls.
      d. Energize lighting management hubs and download system data program.
      e. Address devices.
      f. Verify proper connection of panel links (low voltage/data) and address panel.
      g. Verify system operation control by control.
      h. Verify proper operation of manufacturer's interfacing equipment.
      i. Verify proper operation of manufacturer's supplied PC and installed programs.
      j. Configure initial groupings of ballast for wall controls, daylight sensors and occupancy sensors.
      k. Provide initial rough calibration of sensors; fine-tuning of sensors is responsibility of Contractor unless provided by lighting control manufacturer as part of sensor layout and tuning services where specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS".
      l. Obtain sign-off on system functions.
   4. Conduct third site visit to train Owner's representative on system capabilities, operation, and maintenance, as specified in Part 3 under "Closeout Activities".

3.05 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. Demonstration:

C. Training:

1. Include services of manufacturer's certified service representative to perform on-site training of Owner's personnel on operation, adjustment, and maintenance of lighting control system as part of standard system start-up services.
    a. Include training on software to be provided:
        1) Configuration software used to make system programming and configuration changes.
        2) Control and monitor.

3.07 PROTECTION

A. Protect installed products from subsequent construction operations.

END OF SECTION 26943

SECTION 262200

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. SEIMENS

B. SQUARE D

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

1. Coil Material: Copper.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

E. Taps for Transformers 3 kVA and Smaller: None.

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

H. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150-deg C rise above 40-deg C ambient temperature.

J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

L. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

M. Wall Brackets: Manufacturer's standard brackets.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

B. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

D. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

E. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

   1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

F. Secure transformer to concrete base according to manufacturer's written instructions.

G. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

H. Remove shipping bolts, blocking, and wedges.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

B. Remove and replace units that do not pass tests or inspections and retest as specified above.

C. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.4 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

END OF SECTION 262200

SECTION 262413

SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail utility company's metering provisions with indication of approval by utility company.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer testing agency.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1.6 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Not exceeding 6600 feet.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 SWITCHBOARDS

A. SEIMENS, SQUARE D, GE

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

H. Nominal System Voltage: 208Y/120 V.

I. Main-Bus Continuous: 2500 A.

J. Indoor Enclosures: Steel, NEMA 250, Type 1.
   a. Ventilating openings.

K. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

L. .

M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
   1. Set back from front to clear circuit-breaker removal mechanism.
   2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.

3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

N. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
3. Tin-plated aluminum feeder circuit-breaker line connections.
4. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

A. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

1. SPDs with the following features and accessories:

    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. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

C. 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: 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 208Y/120 V.
3. Line to Line: 1000 V for 208Y/120 V.

D. SCCR: Equal or exceed 100 kA.

E. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long and short time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.

b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
e. 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."
f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
h. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Ratchets to prevent reverse rotation.
8. Removable meter with drawout test plug.
9. Semiflush mounted case with matching cover.
10. Appropriate multiplier tag.

D. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five 15-minute integrated demand of totalized system.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.7 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 NEMA PB 2.1.

B. Install switchboards and accessories according to NECA 400 NEMA PB 2.1.

C. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

D. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to switchboards.
   5. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

F. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

G. Install filler plates in unused spaces of panel-mounted sections.

H. Install overcurrent protective devices, surge protection devices, and instrumentation.

I. Comply with NECA 1.

J. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

K. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

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

1. Acceptance Testing:

   a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
   b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switchboard will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

A. MCCB: Molded-case circuit breaker.

B. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SIEMENS, GE, SQUARE D

2.2 PANELBOARDS COMMON 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 PB 1.

C. Comply with NFPA 70.

D. 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.
c. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.

2. Height: 84 inchesmaximum.

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. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

E. Incoming Mains Location: Convertible between top and bottom.

F. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.

G. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

H. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

I. 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.

J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.3 PERFORMANCE REQUIREMENTS

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2.4 POWER PANELBOARDS

A. Panelboards: NEMA PB 1, distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 incheshigh, provide two latches, keyed alike.

C. Mains: Circuit breaker & Main Lugs only.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices: Fused switches.

G. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: 120-V branch circuit.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker or lugs only.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: 120-V branch circuit.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

    a. RMS sensing.
    b. Field-replaceable rating plug or electronic trip.
    c. Digital display of settings, trip targets, and indicated metering displays.
    d. Multi-button keypad to access programmable functions and monitored data.
    e. Ten-event, trip-history log. Each trip event 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. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
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: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
    f. Shunt Trip: 120-V & 208-V trip coil energized from separate circuit, set to trip at 55 & 75 percent of rated voltage.
    g. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
    h. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.7 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 metal frame with transparent protective cover.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. 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 INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407 NEMA PB 1.1.

C. Mount top of trim 90 inches above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box.

E. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

F. 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.

G. Install filler plates in unused spaces.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. 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.

3.3 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 stated in NETA Acceptance Testing Specification. 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.

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.

END OF SECTION 262416

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Snap switches and wall-box dimmers.
4. Solid-state fan speed controls.
5. Wall-switch and exterior occupancy sensors.
6. Communications outlets.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cooper, Hubbell, Leviton, Pass & Seymour/Legrand

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120V, 20 A:

1. Single Pole:
2. Two Pole:
3. Three Way:
4. Four Way:

2.6 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V,20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

C. Toggle Switches, Square Face, 120 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

D. Telephone Outlet:

1. Per Key West City Hall IT Department standard specifications.

E. Combination TV and Telephone Outlet:
1. Per Key West City Hall IT Department standard specifications.

F. .

2.7 WALL PLATES

A. 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: Smooth, high-impact thermoplastic.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

B. Wall Plate Color: For plastic covers, match device color.

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 meet provisions of 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 down, 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. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience 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.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813

FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
   a. Enclosed switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Bussman, Littelfuse

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 250-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC[**, fast acting**] [**, time delay**].
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC[**, fast acting**] [**, time delay**].
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC[**, time delay**].
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC[**, time delay**].
7. Type T: [**250-V, zero- to 1200-A**] [**600-V, zero- to 800-A**] rating, 200 kAIC[**, very fast acting**] [**, time delay**].

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.2 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 PERFORMANCE REQUIREMENTS

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Siemens, GE, Square D

B. Type HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

A. Type HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Type HD, Heavy Duty, Double Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Suitable for number, size, and conductor material.

2.3 SHUNT TRIP SWITCHES

A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

B. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power source of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

D. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight ON pilot light.
3. Isolated neutral lug.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Form C alarm contacts that change state when switch is tripped.
6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

B. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

C. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.

4. Ground-fault pickup level, time delay, and I^2t response.

D. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

E. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: 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. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.2 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.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, 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 stated in NETA Acceptance Testing Specification. 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.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262816

SECTION 262923

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This specification is to cover a complete Variable Frequency Drive consisting of a pulse width modulated (PWM) inverter designed for use with a standard NEMA Design B induction motor.

B. The drive manufacturer shall supply the drive and all necessary options as herein specified. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable. All VFDs installed on this project shall be from the same manufacturer.

1.02 QUALITY ASSURANCE

A. Referenced Standards and Guidelines:
   1. IEEE 519-1992, Guide for Harmonic Content and Control.
   2. UL508(A)(C)
   3. ICS 7.0, AC Adjustable Speed Drives
   4. EN/IEC 61800-3
   5. NEC 430.120, Adjustable-Speed Drive Systems
   6. IBC 2012 Seismic – referencing ASC 7-05 and ICC AC-156

B. Qualifications:
   1. VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for external input fuses.
   2. CE Mark – The base VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). (RFI / EMI Filter spec).
   3. The entire VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2012 International Building Code (IBC):
      a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
      b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.
      c. Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion by a certified lab.

1.03 SUBMITTALS

A. Submittals shall include the following information:
   1. Outline dimensions, conduit entry locations and weight.
   2. Customer connection and power wiring diagrams.
   3. Complete technical product description include a complete list of options provided.

1.04 BUILDING INFORMATION MODELING (BIM)

A. BIM objects shall contain IFC parameters and associated data applicable to building system requirements. These elements shall support the analytic process including size, clearance, location, mounting heights, and system information where applicable.

PART 2 - PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein and defined on the VFD schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable).
   1. Environmental operating conditions: -15 to 40° C (5 to 104° F) continuous. Altitude 0 to 3300 feet above sea level, less than 95%, non-condensing All circuit boards shall be coated to protect against corrosion.

B. All VFDs shall have the following standard features.
   1. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
   2. The keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
   3. VFDs through 200 HP shall have internal chokes (reactors) providing 5% impedance to reduce the harmonics to the power line and to add protection from AC line transients.
   4. The input current rating of the VFD shall not be greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.122
   5. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus.

C. All VFDs to have the following adjustments:
   1. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close.
   2. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates
   3. The VFD shall include a fireman's override input. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run at a preset speed or in a separate PID mode.

D. Serial Communications

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet).

E. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2).

F. DRIVE OPTIONS – Options shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

G. BYPASS – Bypasses shall be furnished and mounted by the drive manufacturer as defined on the VFD schedule. All VFD with bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. A complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.
2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed.
3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.
4. The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.
5. Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.
6. The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.
7. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet MS/TP.
8. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include "FireStat", "FreezStat", "Over pressure" and "Low suction". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.
9. Smoke Control Override Mode (Override 1) – The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire / Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User's Manual documentation. In this mode, the system will ignore low

priority safeties and acknowledge high priority safeties. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.

10. Fireman's Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for "Run-to-Destruction". The user may also force the unit into Override 2 via the serial communications link.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be the responsibility of the mechanical contractor.
B. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current.
C. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

A. Factory start-up shall be provided for each drive by a factory authorized service center.

3.03 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line connected to factory support personnel located in the US shall be available. Technical support offered only through the local sales office is not acceptable.

3.04 WARRANTY

A. The VFD Product Warranty shall be 36 months from the date of factory shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

END OF SECTION 262923

SECTION 263213

ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. Diesel engine.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Performance requirements for sensitive loads.
5. Sub Base Fuel Tank
6. Outdoor enclosure.

B. Related Sections include the following:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.
2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

B. Source quality-control test reports.

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 test reports.

D. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017800 “Closeout Submittals", include the following:

1. 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.

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. 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.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than (four) (4) hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 99.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

K. Comply with UL 2200.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.9 PROJECT CONDITIONS

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

1. Notify Construction Manager and or Owner no fewer than two (2) days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's and or Owner's written permission.

B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 50 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 100 ft

1.10 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators . Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five (5) Year/ 3000hr Comprehensive from date of Substantial Completion.

1.12 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide MTU Onsite Energy Model DS500D6SPA or a comparable product by one of the following:

B.

1. MTU Onsite Energy by FDDA
2. Caterpillar; Engine Div.
3. Cummins Power Generation; Industrial Business Group.
4.

5. Any changes to the generator set installation requirements due to manufacturers' products differing from the Basis-of-Design Product are the responsibility of the contractor.

2.2 ENGINE-GENERATOR SET

A. 500 kW / 625 kVA, 208 Volt 3 Phase 12w 60Hz packaged engine generator set shall be a coordinated assembly of compatible components

B. Factory-assembled and -tested, engine-generator set.

C. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

D. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated**,** with capacity as required to operate as a unit as evidenced by records of prototype testing

2. Output Connections: 208v, Three-phase, 12 wire, 60 Hz

3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

E. Generator-Set Performance with PMG excitation:

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: .25 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 3-4 seconds.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

6. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

7. Sustained Short-Circuit Current: For a 3-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.

8. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

   a. Provide permanent magnet excitation for power source to voltage regulator.

9. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE (S1600)

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

B. Basic Engine: Grey cast-iron crankcase, Flywheel housing SAE 1, Flywheel 14", Oil pan, Forged crankshaft, forged connecting rods, Four-valve overhead camshaft, Light-metal solid-skirt pistons, Piston cooling via oil spray nozzle, Dry exhaust manifold and vibration damper.

C. Starter: One electric starter 24VDC

D. Fuel System: Common rail fuel injection with low and high pressure fuel pumps, Electronically controlled injection, Main filter, Pre-filter.

E. Rated Engine Speed: 1800 rpm.

F. Generator: Engine mounted belt drive 28v and 55 amp.

G. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

H. Lube Oil System: Forced-feed lubrication system with piston cooling, Lube oil circulating pump with safety valve, Lube oil filter, Lube oil heat exchanger, Filler neck, Dip stick and Closed crankcase breather system.

I. Engine Fuel System:

   1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

   2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

3. Lift Pump: Provides adequate pressure to the main fuel pump mounted on the engine.

4. Single Canister Fuel Water Separator: Single filter element fuel water separator rated to remove a minimum of 30 microns and smaller while passing full flow.

J. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system , properly sized to maintain engine jacket water at 90 degrees and suitable for operation in an ambient temperature of 20°F. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. (208v 1ph)

K. Governor: Electronic Control through ECU, with speed sensing.

L. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.

b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

M. Muffler/Silencer: Hospital, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 40 dB at 500 Hz.

2. An exhaust silencer and flexible stainless steel exhaust fitting shall be furnished and installed inside the generator weather proof enclosure.

3.

N. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

O. Starting System: 24-VDC electric starter, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" 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: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.

7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 55-A minimum continuous rating.

8. Battery Charger: 12 or 24 VDC, current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

   a. Operation: Minimum equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.

   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus .5 percent.

   d. Ammeter and Voltmeter: Digital Display 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.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: 2400 gln factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for 72 hours' continuous operation at 100 percent rated power output.
3. Emergency tank and basin vents.
4. Mechanical level gauge.
5. Fuel supply and return lines, connected to generator set with flexible fuel lines, as recommended by the engine manufacturer, and in compliance with UL2200 and NFPA requirements.
6. Leak detection provisions, wired to the generator set control for local and remote alarm indication.
7. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
8. Basin drain.
9. Integral lifting provisions.
10. Vandal-resistant fill cap.
11. Containment Provisions: Comply with requirements of authorities having jurisdiction.
12. Florida Department of Environmental Protection Approved.

2.5 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 generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements

automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. 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 generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch(es).
9. Generator-voltage adjusting rheostat.
10. Fuel tank derangement alarm.
11. Fuel tank high-level shutdown of fuel supply alarm.
12. Generator overload.
13. Ground fault indication from emergency gear.

E. 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.

F. Connection to Data Link: A separate terminal block, factor wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Section 260913 “electrical Power Monitoring and Control.”

G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

H. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.

1. Engine high-temperature shutdown.
2. Lube-oil, low-pressure shutdown.
3. Overspeed shutdown.
4. Remote emergency-stop shutdown.
5. Engine high-temperature pre-alarm.
6. Lube-oil, low-pressure pre-alarm.
7. Fuel tank, low-fuel level.
8. Low coolant level.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, Electronic Trip Type type; 100 percent rated; complying with NEMA AB 1 and UL 489.

B. Product Description: Enclosed, molded-case circuit breaker conforming to NEMA AB 1 and FS-W-C.

C. Solid-State Circuit Breaker: Electronic sensing, timing, and tripping circuits for adjustable current settings; instantaneous trip; and adjustable short time trip.

1. Tripping Characteristic: Designed specifically for generator protection.

2. Trip Rating: Matched to generator rating.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices. 24 volts, DC.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

1. Initiates a generator overload pre-alarm when generator has operated at an overload equivalent to 105 percent of full-rated load for 5 seconds. Indication for this alarm is integrated with other generator set malfunction pre-alarms.

2. Indicates a generator overload alarm when generator has operated at an overload equivalent to 105 percent of full-rated load for 300 seconds. Indication for this alarm is integrated with other generator set malfunction alarms.

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 generator set.

4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

E. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 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 or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. 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.

F. Enclosure: Drip proof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

(DVR2000EC)

1. True RMS Sensing – One or Three Phase Connect the sensing mode you prefer. Senses 95 to 600 volts ±10% at 50/60 hertz. Patented circuitry senses true RMS voltage rather than average for superior load regulation.
2. Soft-Start Ramp on Initial Start-Up Controlled increase to rated voltage. Limits overshoot of voltage during voltage build-up.
3. Engine Unloading Monitors the rate of frequency change during transient conditions. Provides additional voltage dip during speed drop to allow engine to recover faster.
4. Overvoltage Shutdown Provides generator protection during sustained overvoltage. The overvoltage point is preset at 20% over normal generator operating voltage, with a preset timeout of 0.75 seconds.
5. VAR or PF control can be selected or changed by regulator adjustment.

1.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Minimum capability of SKVA at 30% voltage dip: 1500

L. Subtransient Reactance: 10.8 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof aluminum housing, wind resistant up to 200 mph. ASCE 7-05 Exposure C, 3-second wind gusts

B. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

C. Description: Prefabricated or pre-engineered skin tight enclosure with the following features:

1. Construction:

2. Description: Aluminum enclosure with the following features:

3. 1. Construction: Formed and/or welded aluminum.

4. 2. Hinged doors for access with lockable latches. Padlockable Stainless Steel Handles.

5. 3. Louvered and/or baffled air inlet. Grated air outlet.

6. 4. Interior lined with acoustical foam for sound attenuation.

7. 5. Intake and exhaust scoops installed to meet sound requirements.

8. 6. Choice of standard colors. Custom colors available upon request.

9. 7. Additional Enclosure Features:

a. Exhaust Scoop

10. Aluminum housing extension intended to redirect exhaust air vertical instead of horizontal to increase sound attenuation.

b. Sound Attenuation

11. Provide housing insulation resulting in a minimum of - 30dB(A) attenuation at 23-feet distance. In no case shall the sound level exceed 63.5 dB (A) at a distance of 23-feet.

c. Door Restraints

12. Hardware installed to secure doors in the open position to aide in service and operation.

d. DC Lighting

13. Consists of one or more (dependent upon enclosure size) vapor-proof UL listed light fixtures prewired in conduit to a customer connection point.

14. Operates on 12/24Vdc and is controlled by choice of prewired SPST switch or countdown timer.

15. Structural Design and Anchorage: Comply with ASCE 7 for wind loads and the Florida Building Code

16. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents. Vertical plenum air discharge.

17. Muffler Location: Within enclosure.

18.

19. Convenience Outlets: Factory wired GFCI. Arrange for external electrical connection

2.9 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 base plates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Neoprene Pad
2. ¼ inch thick elastomeric pad in square shape to be placed under the base frame at each of the pre-drilled isolator mounting holes.
3. Helps to prevent sliding of the unit as well as reducing the transmission of sound and vibration into the floor.

2.10 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set 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. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.

6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. 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 of 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 packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with integral isolators and elastomeric isolator pads on minimum 6-inch high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. 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 Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FACTORY TESTING

A. Prototype Testing: factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

B. 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

C. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set 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. Full Load Run.
3. Maximum Power.
4. Voltage Regulation.
5. Transient and Steady-State Governing.
6. Single-Step Load Pickup.
7. Safety Shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Contractor to engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

2. Perform Four (4) Hour NFPA 110 Load bank 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 (120kPa). 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. Noise Level Tests: Provide calculated noise measurement of the complete generator package.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

I. Remove and replace malfunctioning units and retest as specified above.

J. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

K. Report results of tests and inspections in writing within two weeks to Owner/Engineer.

L. Parts, Operation Instructions, and Maintenance Manuals:

   a. After completion of work, and satisfactory start-up and testing of the EG system at the project site, deliver to the Engineer a quantity of four (4) copies of the generator equipment parts, operation instructions, maintenance manuals and drawings presenting full details for proper operation, care and maintenance of each item of equipment provided for the EG system under this Contract.

   b. Each manual shall contain the operating and maintenance information and parts breakdowns and lists for all equipment provided under this Contract. When necessary, provide supplemental drawings to show system operation and servicing and maintenance points. For all electrical equipment and components, provide complete, as field installed and wired electrical wiring schematics and connection diagrams. The manuals shall include instructions required to accomplish all specified EG system operations and functions. Data shall be neat, clean, legible copies. Drawings larger than standard size notebook paper shall be accordion folded. Specific equipment furnished for the EG system shall be clearly identified in the manuals. All non-applicable information shall not be included or must be sufficiently crossed out in each of the furnished manuals.

3.7 DEMONSTRATION

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

END OF SECTION 263213

SECTION 263353

STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 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. Static bypass transfer switch.
   e. Battery and battery disconnect device.
   f. Battery monitoring.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement. Include wiring diagrams.

1.3 INFORMATIONAL SUBMITTALS

A. Factory Test Reports: Comply with specified requirements.

B. Field quality-control reports.

C. Warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 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: Listed and labeled under UL 1778 by an NRTL.

C. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

1.6 WARRANTY

A. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to 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	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

2. Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to 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: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. 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.
2. 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.
3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If the battery is disconnected, the UPS continues to supply power to the load 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 in subparagraphs 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 either 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: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet.

2.2 PERFORMANCE REQUIREMENTS

A. 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 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. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is [**30**] [**50**] [**100**] percent unbalanced continuously.

B. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is 15 minutes.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 percent from nominal voltage.

D. Overall UPS Efficiency: Equal to or greater than 90 percent at 100 percent load, 90 percent at 75 percent load, and 90 percent at 50 percent load.

E. Maximum Energizing Inrush Current: Six times the full-load current.

F. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

G. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

H. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to [**5**] [**10**] percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
2. Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

I. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

J. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.

K. 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 100 ms:

1. 50 Percent: Plus or minus 5 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.

L. Input Power Factor: A minimum of 0.85 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.

M. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

A. Eaton Powerware, Precision Environment, Mitsubishi

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

E. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer 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 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.4 RECTIFIER-CHARGER

A. 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.

B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.5 INVERTER

A. Description: Pulse-width modulated, with sinusoidal output.

2.6 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

2.7 BATTERY

A. Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

2.8 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: Plain-language messages on a digital LCD or 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 overfrequency or underfrequency.
c. Bypass ac input and inverter out of synchronization.
d. Bypass ac input wrong-phase rotation.
e. Bypass ac input single-phase condition.
f. Bypass ac input filter fuse blown.
g. Internal frequency standard in use.
h. Battery system alarm.
i. Control power failure.
j. Fan failure.
k. UPS overload.
l. Battery-charging control faulty.
m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.

4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.9 MONITORING BY REMOTE STATUS AND ALARM PANEL

A. Description: Labeled LEDs on panel faceplate indicate 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: Surface or flush mounted to suit mounting conditions indicated.

2.10 BASIC BATTERY MONITORING

A. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

B. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.

C. Annunciation of Alarms: At UPS control panel.

2.11 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
2. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
4. Alarm Contacts: Arranged to initiate local remote alarm for battery discharge events abnormal temperature abnormal battery voltage or temperature.

5. Memory: Stores recorded data in nonvolatile electronic memory.
6. RS-232 Port: Permits downloading of data to a portable PC.
7. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

2.12 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use simulated battery testing. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Report test results.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
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.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

D. Grounding 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.

E. Identify components and wiring according to Section 260553 "Identification for Electrical Systems."

F. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.2 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. Comply with manufacturer's written instructions.
2. Inspect interiors of enclosures, including the following:

   a. Integrity of mechanical and electrical connections.
   b. Component type and labeling verification.
   c. Ratings of installed components.

3. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
4. Test manual and automatic operational features and system protective and alarm functions.
5. Test communication of status and alarms to remote monitoring equipment.

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

D. 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.

E. Prepare test and inspection reports.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

SECTION 263600

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 Scope

Furnish and install automatic transfer switches (3ATS) with number of poles, amperage, voltage, and withstand current ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch unit and a microprocessor controller, interconnected to provide complete automatic operation. All transfer switches and control panels shall be the product of the same manufacturer.

1.02 Acceptable Manufacturers

Automatic transfer switches shall be ASCO Series 300 (3ATS). Any alternate shall be submitted to the consulting engineer in writing at least 10 days prior to bid. Each alternate bid must list any deviations from this specification.

1.03 Codes and Standards

The automatic transfer switches and accessories shall conform to the requirements of:

A. UL 1008 - Standard for Automatic Transfer Switches

B. CSA C22.2 No.178 – 1978

C. NFPA 70 - National Electrical Code

D. NFPA 99 – Health Care Facilities

E. NFPA 110 - Emergency and Standby Power Systems

F. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

G. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches

H. NEC Articles 700, 701, 702

I. International Standards Organization ISO 9001: 2008

J. IEC 60947 – 6 – 1

PART 2 PRODUCTS

2.01 Mechanically Held Transfer Switch

A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include over current disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible positions, normal or emergency.

B. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.

C. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented blow-on construction for high withstand current capability and be protected by separate arcing contacts.

D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.

E. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

F. Where neutral conductors must be switched, the 3ATS shall be provided with fully-rated neutral transfer contacts.

G. Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.

2.02 Group 'G' Controller with Integrated User Interface Panel

A. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.

B. The controller shall direct the operation of the transfer switch. The controller's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, inherent serial communications capability, and the ability to communicate via the Ethernet through optional communications module

C. A single controller shall provide single and three phase capability for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to ± 1% of nominal voltage. Frequency sensing shall be accurate to ± 0.1Hz. Time delay settings shall be accurate to ± 0.5% of the full scale value of the time delay. The panel shall be capable of operating over a temperature range of -20 to + 70 degrees C, and storage from -55 to + 85 degrees C.

D. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards.

E. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:

1. IEEE C37.90
2. IEC 60947 – 6 - 1, 61000-4
   a. IEC 61000 – 4 - 2 Electrostatic Discharge Immunity
   b. IEC 61000 – 4 - 3 Radiated RF Field Immunity

c. IEC 61000 – 4 - 4 Electrical Fast Transient/Burst Immunity

d. IEC 61000 – 4 - 5 Surge Immunity

e. IEC 61000 – 4 – 6 Conducted RF Immunity

3. CISPR 11 – Conducted RF Emissions and Radiated RF Emissions

2.03 Enclosure

A. The 3ATS shall be furnished in a NEMA type 1 enclosure unless otherwise shown on the plans.

B. Provide strip heater with thermostat for Type 3R enclosure requirements.

C. Controller shall be mounted on, visable, and operational through enclosure door.

PART 3 OPERATIONS

3.01 Controller Display and Keypad

A. A 128*64 graphical LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters.
Operational parameters shall also be available for viewing and limited control through communications port. The following parameters shall only be adjustable via DIP switches on the controller.

1. Nominal line voltage and frequency

2. Single or three phase sensing on normal, and single phase sensing on emergency

3. Transfer operating mode configuration, (open transition, or delayed transition)

All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

3.02 Voltage and Frequency Sensing

A. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup,dropout, and trip settings capabilities (values shown as % of nominal unless otherwise specified.

Parameter	Sources	Dropout/Trip	Pickup/Reset
Undervoltage	N & E	70 to 98%	85 to 100%
Overvoltage	N & E	102 to115%	2% below trip
Undervoltage	N & E	85 to 98%	90 to 100%
Overfrequency	N & E	102 to 110%	2% bellow trip

B. Repetitive accuracy of all settings shall be within 1% at +25C

C. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.

D. Source status screens shall be provided for both normal & emergency to provide digital readout of voltage on all 3 phases, and frequency.

E. The backlit 128*64 graphical display shall have multiple language capability. Languages can be selected from the user interface.

3.03 Time Delays

A. A time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals, adjustable 0 to 6 seconds. It shall be possible to bypass the time delay from the controller user interface.

B. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes 59 seconds for controlled timing of transfer of loads to emergency. It shall be possible to bypass the time delay from the controller user interface.

C. A generator stabilization time delay shall be provided after transfer to emergency adjustable 0 or 4 seconds.

D. A time delay shall be provided on retransfer to normal, adjustable 0 to 9 hours 59 minutes 59 seconds. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.

E. A cooldown time delay shall be provided on shutdown of engine generator, Adjustable 0 to 60 minutes 59 seconds.

F. All adjustable time delays shall be field adjustable without the use of special tools.

G. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minutes 59 seconds time delay in any of the following modes:

1. Prior to transfer only.

2. Prior to and after transfer.

3. Normal to emergency only.

4. Emergency to normal only.

5. Normal to emergency and emergency to normal.

6. All transfer conditions or only when both sources are available.

H. In the event that the alternate source is not accepted within the configured Failure to Accept time delay, the common alert indication shall become active.

I. The controller shall also include the following built-in time delay for delayed transition operation.

1. A time delay for the load disconnect position for delayed transition operation adjustable 0 to 5 minutes 59 seconds.

3.04 Additional Features

A. The user interface shall be provided with test/reset modes. The test mode will simulate a normal source failure. The reset mode shall bypass the time delays on either transfer to emergency or retransfer to normal.

B. A set of contacts rated 2 amps, 30 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down. setting, regardless of whether the normal source restores before the load is transferred.

C. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of two contacts, closed when the ATS is connected to the normal source and two contacts closed when the ATS is connected to the emergency source.

D. A single alarm indication shall light up the alert indicator and de – energize the configured common alarm output relay for external monitoring.

E. LED indicating lights shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

F. LED indicating lights shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal (green) and emergency (red) source, as determined by the voltage sensing trip and reset settings for each source.

G. LED indicating light shall be provided to indicate switch not in automatic mode (manual); and blinking (amber) to indicate transfer inhibit.

H. LED indicating light shall be provided to indicate any alarm condition or active time delay (red).

The following features shall be built – in to the controller, but capable of being activated through keypad programming or the serial port only when required by the user:

I. Provide the ability to select "commit/no commit to transfer" to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

J. A variable window inphase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer. The inphase monitor shall be equal to ASCO feature 27.

K. An engine generator exercising timer shall be provided to configure weekly and bi-weekly automatic testing of an engine generator set with or without load for 20 minutes fixed. It shall be capable of being configured to indicate a day of the week, and time weekly testing should occur.

The following feature shall be built – into the controller, but capable of being activated through keypad programming,communications interface port, or additional hardware.

L. Terminals shall be provided for a remote contact to signal the ATS to transfer to emergency. This inhibit signal can be enabled through the keypad or serial port.

M. System Status - The controller LCD display shall include a "System Status" screen which shall be readily accessible from any point in the menu by depressing the "ESC" key. This screen shall display a clear description of the active operating sequences and switch position. For example,

Normal Failed
Load on Normal
TD Normal to Emerg
2min15s

Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual are not permissible.

N. Self Diagnostics – The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.

O. Communications Interface – The controller shall be capable of interfacing, through an optional serial communication port with a network of transfer switches, locally (up to 4000 ft.). Standard software specific for transfer switch applications shall be available by the transfer switch manufacturer. This software shall allow for the monitoring, control, and setup of parameters.

P. Data Logging – The controller shall have the ability to log data and to maintain the last 300 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non – volatile memory.

1. Event Logging

    1. Data and time and reason for transfer normal to emergency
    2. Data and time and reason for transfer emergency to normal
    3. Data and time and reason for engine start
    4. Data and time engine stopped
    5. Data and time emergency source available
    6. Data and time emergency source not available

2. Statistical Data

    1. Total number of transfers
    2. Total number of transfers due to source failure
    3. Total number of day's controller is energized
    4. Total number of hours both normal and emergency sources are Available
    5. Total time load is connected to normal
    6. Total time load is connected to emergency
    7. Last engine start
    8. Last engine start up time
    9. Input and output status

4.01 Optional Features (The following section is optional and should be deleted if not required)

A. Accessory Package - An accessory bundle shall be provided that includes:

1. A fully programmable engine exerciser with seven independent routines to exercise the engine generator, with or without load on a daily weekly, bi – weekly, or monthly basis.

2. Event log display that shows event number, time and date of events, event type, and reason (if applicable). A minimum of 300 events shall be stored.

3. RS – 485 communications port enabled.

4. Common alarm output contact.

(This feature shall be equal to ASCO accessory 11BE, and shall be capable of being activated for existing switches through optional accessory dongle).

B. Controller Power Supply - A backup power UPS shall be provided to allow controller to run for 3 minutes minimum without AC power. (This feature shall be equal to ASCO accessory 1UP, and shall be capable of being added to existing switches without modification).

C. Expansion Module - A relay expansion module (REX) is a standard feature when delayed transition transfer is specified. A REX module shall also be provided for open transition transfer that includes one form C contact for source availability of the normal (18G) and emergency (18B) sources. Additional output relay shall be provided to indicate a common alarm. The REX module shall have the capability of being daisy chained for multiple sets of contacts. (This feature shall be equal to ASCO accessory 18RX, and shall be capable of being added to existing switches without modification).

D. Current Sensing Card - A load current metering card shall be provided that measures either single or three phase load current. It shall include current transformers (CT's) and shorting block. Parameters shall be able to be viewed via the user interface. (This feature shall be equal to ASCO accessory 23GA (single phase), 23GB (three phase), and shall be capable of being added to existing switches without modification).

E. Communication Interface - A Quad – Ethernet module shall be provided to allow several different serial devices that communicate at different baud rates and with different protocols to a common Ethernet media. The module shall be used to connect Series 300 and ASCO ATS Annunciators to the standard Ethernet network. It shall include (2) RJ – 45, (2) RS – 485, (2) TTL, and (2) CAN ports. The module shall be designed to communicate with multiple clients such as Web Browsers, and PowerQuest® systems simultaneously over the Ethernet connection. (This feature shall be equal to ASCO accessory 72EE, and shall be capable of being added to existing switches without modification).

F. Transfer Alarm - An audible alarm with silencing feature shall be provided to signal each time transfer to emergency occurs. (This feature shall be equal to ASCO accessory 62W).

G. Load Shed Circuit (Contact) – A load shed shall be initiated by opening of customer supplied contact to match generator set capacity to the load. Relay de – energization opens emergency contactor (CE) disconnecting the load from the emergency source. If the normal source is acceptable,normal source contactor (CN) is closed to connecting the load to the normal source. When the load is reconnected to normal the control panel is reset in readiness for the next normal source failure. (This feature shall be equal to ASCO accessory 30A).

Load Shed Circuit (Voltage) – A load shed shall be initiated by the removal of the control voltage to a relay to match generator capacity to the load. Relay de – energization opens emergencey contactor (CE) disconnecting the load from emergency source. If the normal source is acceptable, normal source contactor (CN) is closed connecting the load to the normal source. When the load is reconnected to normal the control panel is reset in readiness for the next normal source failure. (This feature shall be equal to ASCO accessory 30B*).
* User control voltages: 12, 24, 32, 48, 120 Vdc, and 120 Vac.

H. Enclosure Heater - A 125 watt enclosure heater with transformer and thermostat (adjustable from 30° to 140 ° F) shall be provided for outdoor installations where type 3R, 4, are specified. (This feature shall be equal to ASCO accessory 44G, and shall be capable of being added to existing switches).

I. Surge Suppression – A TVSS with a surge current rating of 65kA shall be provided with individually matched fused metal oxide varistors (MOVs). It shall include LED status indication of normal operation, under voltage, power loss, phase loss or component failure. Shall include form C dry contacts for external alarm or monitoring. The unit shall be enclosed in a Noryl housing rated NEMA 4, 12, and 4X. Shall comply with UL 1449 3rd edition (This feature shall be equal to ASCO accessory 73, and shall be capable of being added to existing switches).

J. Power Meter (This feature shall be equal to ASCO accessory 135L).

1. Furnish Power Meters at locations shown to monitor all functions specified below.

2. The Power Meters shall be listed to UL3111-1,CSA,CE Mark, and industrially rated for an operating temperature range of -20◦C to 60◦C.

3. The Power Meter shall be accuarte to 1% measured, 2% computed values and display resolution to 1%. Voltage and current for all phases shall be sampled simultaneously to assure hig accuracy in conditions of low power factor or large waveform distortions (harmonics).

4. The Power Meter shall be capable of operating without modification at nominal Frequencies of 45 to 66Hz and over a control power input range of 9 – 36VDC.

5. Each Power Meter shall be capable of interfacing with an optional communications module to permit information to be sent to central location for display, analysis, and logging.

6. The Power Meter shall accept inputs from industry standard instrument transformers (120 VAC secondary PTs and 5A secondary CTs). Direct phase voltage connections, 600 VAC and under, shall be possible without the use of PTs.

7. The Power Meter shall be applied in single, 3 phase, or three & four wire circuits. A fourth CT input shall be available to measure neutral or ground current.

8. All setup parameters required by the Power Meter shall be stored in non – volatile memory and retained in the event of a control power interruption.

9. The following metered readings shall be communicated by the Power Meter, via

serial communication, when equipped with optional serial communications module.

a) Current, per phase RMS and neutral (if applicable)
b) Current Unbalance %
c) Voltage, phase – to – phase and phase – to – neutral
d) Voltage Unbalance %
e) Real power (KW), per phase and 3 – phase total
f) Apparent power (KVA), per phase and 3 – phase total
g) Reactive power (KVAR), per phase and 3 – phase total
h) Power factor, 3 – phase total & per phase
i) Frequency
j) Accumulated Energy, (MWH, MVAH, and MVARH)
k) Total Harmonic Distortion

The following energy readings shall be communicated by the Power Meter:

a) Accumulated real energy KWH
b) Accumulated reactive energy KVAH
c) Accumulated apparent energy KVARH

Note: For real reactive energy reported values, separate total for energy flow from each source shall be stored, including the arithmetic sum.

*Note Spec Writer: The following section is optional and should be deleted if not used.
The Power Meter shall flush mount to an enclosure

1. The Power Meter shall be equipped with an optional continuous duty, long life, 4 line x 20 character LCD backlit display to provide local access to the following metered quantities:

   a) Current per phase RMS and neutral (if applicable)
   b) Current Unbalance %
   c) Voltage, phase – to – phase and phase – to – neutral
   d) Voltage Unbalance %
   e) Real power, per phase and 3 – phase total
   f) Apparent power, per phase and 3 – phase total
   g) Reactive power, per phase and 3 – phase total
   h) Power factor, 3 – phase total & per phase
   i) Frequency
   j) Accumalted Energy, (MWH,MVAH, and MVARH)
   k) Total harmonic distortion

2. Displaying each of the Power Meter quantities shall be accomplished through the use of menu scroll buttons.

3. For ease in operator viewing, the display shall remain on continuously, with no detrimental effect on the life of the Power Meter.

4. Setup for system requirments shall be allowed from the front of the Power Meter. Setup provisions shall include:

   a) CT rating (xxxxx:5)
   b) PT rating (xxxxxxx:120) (if applicable; 24000V maximum)
   c) System type (single; three phase; 3 and 4 wire

d) Communication parameters

5. Reset of the following electrical parameters shall also be allowed from the front of the Power Meter:

   a) Real energy (MWH), apparent energy (MVAH) and reactive energy (MVARH).

6. All reset and setup functions shall have a means for protection against unauthorized/accidental changes.

J. Power Monitoring and Control

A PowerQuest ® PC based Automatic Transfer Switch (ATS) remote monitoring and control system designed to communicate with other ATSs located in remote locations shall be provided. System shall utilize serial communications capability inherent with the ATS microprocessor based control panel offering. Refer to separate Suggested Specification.

A SiteWeb™ remote monitoring and control system that is accessible from any network connected pc. It shall be an internet browser based system that can be configured to remotely monitor and control from a pc connected to the internet. Refer to separate Suggested Specification.

PART 5 ADDITIONAL REQUIREMENTS

5.01 Withstand and Closing Ratings

A. The ATS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans. WCR ATS ratings shall be as follows when used with specific circuit breakers:

ATS Size	Withstand & Closing Rating MCCB (480v/60hz)	W/CLF
30	10,000A	100,000
70 - 200	22,000A	200,000
230	22,000A	100,000
260 – 400	42,000A	200,000
600	50,000A	200,000
800 – 1200	65,000A	200,000
1600 – 2000	85,000A	200,000
2600 – 3000	100,000A	200,000

5.02 Tests and Certification

A. The complete 3ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

B. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial

number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

C. The ATS manufacturer shall be certified to ISO 9001: 2008 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001: 2008.

5.03 Service Representation

A. The ATS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

C. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.

END OF SECTION 263600

SECTION 264113

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. General: Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work specified of this section.

1.02 DESCRIPTION

A. General: Provide a complete lightning protection system as indicated on the drawings and as specified herein. The lightning protection system shall be installed by a firm presently engaged in installations of Master Labeled or LPI certified lightning protection systems. The system as completed shall comply with the latest edition of UL96A, Installation Requirements for Lightning Protection Systems, and NFPA-780 "Standard for the Installation of Lightning Protection Systems." The system shall meet all requirements of these standards and the Lightning Protection Institute Standard of Practice LPI-175. All components required for a UL master label and a full LPI certification plate shall be provided whether or not such materials are specifically addressed by the contract drawings or described herein.

B. Qualification: All installers shall be experienced with installing UL master labeled and LPI certified systems or of equivalent qualification, as accepted in writing by the engineer of record. A UL/LPI certified installer shall be on the project site at all times during installation of the systems and shall supervise all of the installation.

1.03 COUNTERPOISE CONDUCTOR

A. General: Where indicated on the drawings or required by NFPA 780, the structure shall be provided with a below-grade continuous counterpoise conductor, equal in size to the largest conductor in the building lightning protection system, or sized as indicated on the drawing. This conductor shall be installed at a minimum depth of two feet below finished grade and a minimum of two feet from the exterior foundation wall of the building. The counterpoise conductor shall be copper and extend continuously around the entire perimeter of the building. All joints and connections shall be exothermically welded.

B. Counterpoise: As a minimum, the counterpoise conductor shall be connected to each of the following system components utilizing appropriate exothermic welds:

1. Each down conductor or steel column ground.

2. All counterpoise conductors on power and communications ducts which enter the building.

3. The building electrical service ground.

4. All metallic water and gas services entering the building (ahead of meter).

5. Counterpoise conductor on adjacent buildings (within fifty feet).
6. All metallic fence posts, safety railings, etc., or any other metallic item within ten feet of the project building.

1.04 SUBMITTALS

A. General: Shop drawings identifying all system wiring and component placement, including all details, shall be submitted to the Engineer for review. The Contractor shall not perform any portion of the Work until the respective submittal has been accepted. All work shall be in accordance with accepted submittals.

B. Detail Submission: Details shall be submitted to the Engineer for review indicating the method of cabling connections and attachments starting at the top of the project building to the ground rods at the counterpoise. All details shall be appropriate for the project.

C. Identification: All product data sheets submitted, for proposed system components, shall clearly identify the item being submitted and shall indicate the UL label.

D. Suppression Device: All transient voltage surge suppressors for the project shall be submitted at the same time as the lightning protection floor plans, details and product data sheets are submitted. Each suppressor shall clearly indicate the item to be protected and shall comply with Section 16709 of these specifications. Suppressors shall be provided as required in NFPA 780 unless otherwise indicated on the drawings or otherwise specified.

E. Deviations: The Contractor shall not be relieved of responsibility for deviations from requirements of the Contract Documents by the acceptance of shop drawings, product data, samples or similar submittals unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submittal and the Engineer has given written acceptance to the specific deviation.

F. Certification: Provide documentation of UL master label, LPI certification or equivalent qualification of exact installer intended to do this particular job.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Labels: All materials used for the system installation shall comply in size, composition and weight to all requirements of NFPA U.L. and LPI for the class of system in which they are installed. All materials shall be labeled or listed by Underwriters Laboratories, Inc. for use in master labeled or LPI certified lightning protection systems.

B. Material: Generally, the external lightning protection system at the roof level shall be constructed of copper cable and copper compatible components. The internal lightning protection system, starting with the down conductors and concluding at the ground termination system shall be constructed of copper cable and copper compatible components. Likewise, all bonding conductors, equipotential loop conductors, etc, shall also be constructed of compatible cable and components.

C. Compatibility: All portions of the system, whether copper or aluminum, shall be galvanically compatible to the building material to which they are to be attached. Connections between copper and aluminum portions of the system shall be made with appropriate bimetallic coupling devices. In all areas, the conductor shall be supported to maintain clearance from all galvanically incompatible materials or shall be of the same material if permitted within these specifications.

D. Components: All system components (i.e. air terminals, bases, connectors, cable, thru-roof fittings, ground rods, etc.) shall be, to the maximum extent possible, the product of a single manufacturer. All components shall be Class I or II as required by NFPA 780 or as noted. All air terminal bases shall be securely mounted to the building structure by means of mechanical fasteners. Adhesive type air terminal bases are acceptable only where hard setting epoxy adhesive is utilized, where mechanical fastening is prohibited by the roofing manufacturer and where acceptable to the code authority having jurisdiction. Submit shop drawings for all proposed air terminal mounting details.

2.02 AIR TERMINALS

A. General: Air Terminals shall be copper as required to match the building system to which they attach. Air terminals shall protrude a minimum of 10 inches above the object to be protected. Center roof terminals shall be 24” high. Air terminal points shall be blunt with the radius of curvature equal to the rod diameter.

B. Base: Each air terminal shall be equipped with the correct type of base for the location in which it is mounted.

C. Roof Top Equipment: Air terminals and interconnecting cable shall be provided for all roof mounted equipment (fans, A/C equipment, etc.) subject to a direct strike as required by NFPA 780 and as shown.

2.03 CONDUCTORS

A. General: Main roof conductors shall be copper unless otherwise specified or required and shall provide a two-way path from each air terminal horizontally or downward to connections with down conductors. Conductors shall be free of excessive splices and bends. No bend of a conductor shall form an included angle of less than 90 degrees nor have a radius of bend of less than 8 inches. Conductors shall be secured to the structure at intervals not exceeding 3 feet with approved fasteners. Cables connected to "thru-roof" connectors may rise from the roof to the connector at a maximum slope of 3 inches per foot, not exceeding 3 feet horizontally in air.

B. Down Conductors: Down conductors shall be copper and shall be concealed in the exterior wall construction or structural columns. Where run in or on reinforced concrete columns, bond down conductor to the re-bar at top and bottom of column. Down conductors shall be spaced at intervals averaging not more than 100 feet around the perimeter of the structure. If project structure is of structural steel frame construction, down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the perimeter of the structure. Connections to the steel frame shall be made with heavy duty bonding plates having 8 square inches of contact surface or with exothermic welds.

C. Shop Drawing: Submit all conductor types in shop drawings. Each conductor shall be identified as to location in the lightning protection system.

2.04 ROOF PENETRATIONS

A. General: Roof penetrations required for down conductors or for connections to structural steel framework shall be made using pre-manufactured U.L. approved thru-roof type assemblies with solid rods, PVC sleeves and appropriate roof flashing. Roof flashing shall be compatible with the roofing system and shall be provided under this contract and installed by the roofing contractor. Submit roof flashing data sheets and letter of acceptance from roofing contractor in shop drawing package.

2.05 COMMON GROUNDING

A. General: Common grounding of all ground mediums within the project building shall be made by interconnecting with main size conductors, fittings as required or exothermic welds.

B. Bonding: Grounded metal bodies located within the required bonding distance (as determined by the bonding distance formulas in NFPA 780) shall be bonded to the system using bonding conductors and fittings. Bond to rebar utilizing mechanical connections.

2.06 GROUND TERMINATIONS

A. General: One ground termination shall be provided for each down conductor and shall consist of one ¾" inch x 10 foot copper-clad ground rod. Each down conductor shall be connected to the ground rod by an exothermic weld connection. Tops of ground rods shall be located 2 feet below finished grade and 2 feet from the foundation wall and shall extend a minimum of 10 feet vertically into the earth. Where a counterpoise is provided, rods shall be interconnected with the counterpoise.

B. General: Where the structural steel framework is utilized as the down conductor for the system, every other perimeter steel column shall be grounded but no more than 60 feet apart. Steel columns shall be grounded using bonding plates having 8 square inches of surface contact area or with exothermic welds. Conductors from the steel column connections to the ground terminations shall be full size copper lightning conductors.

2.07 FASTENERS

A. General: Conductor fasteners shall be manufactured of a material which is compatible with the type of conductor being supported. Fasteners shall be of sufficient strength to properly support each conductor or terminal base, etc.

2.08 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Equipment manufactured by ERICO, INC.

B. Certified Installer: BONDED LIGHTNING PROTECTION SYSTEMS, INC.
2080 W. INDIANTOWN ROAD, SUITE 100
JUPITER, FL 33458 561/746-4336

C. Approved Equal

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUCTORS

A. General: Conductors shall be installed to interconnect all air terminals to the system of grounding electrodes, and in general provide a minimum of at least 2 paths to ground from any air terminal on the system. Conductors shall provide a horizontal or downward path between the system air terminals and grounding electrode system.

B. Routing: Conductors shall be routed in such a manner that maximum concealment from public view is achieved. Down conductors may be installed in one-inch PVC conduit from roof to grade.

C. Counterpoise Conductors: Counterpoise conductors shall be installed after finished grades are established to insure specified depth and to minimize the

possibility of damage. Any counterpoise conductor which is cut or damaged shall be repaired or replaced with no additional cost to the contract.

D. Connections: All connections between conductors below grade shall be exothermically welded. Improper application of weld shall be replaced at no additional cost to the contract.

3.02 INSTALLATION OF GROUND RODS

A. General: Ground rods shall be installed vertically at each down conductor position at a minimum of 2 feet from the building foundation wall. Inspection and documentation at each grounded location, weld, depth of counterpoise, etc., shall be made prior to backfill. Contractor shall notify engineer in writing to request inspection of underground work and for L.P.I. inspection before backfill. Allow a minimum of one week for engineer to make the inspection after notification from contractor.

3.03 BONDING OF SECONDARY METALLIC BODIES

A. Structure Grounding: Provision shall be made at the roof level on reinforced concrete structures for bonding between the roof or down conductors, metallic elements of the roof system and metallic exterior wall systems.

B. Bonding: All down conductors run in concrete columns shall be bonded to the reinforcing steel at the top and the bottom of the column.

3.04 GENERAL WORKMANSHIP

A. General: All elements of the Lightning Protection System shall be installed in a professional and workmanlike manner consistent with the best industry practices.

B. Concealed Installation: All system components shall be concealed to the maximum extent possible to preserve the aesthetic appearance of the project building on which the system is installed.

3.05 COORDINATION WITH OTHER TRADES

A. Coordination: The Contractor shall coordinate his work with all trades, to insure the use of proper materials and procedures in and around the roof in order not to jeopardize the roofing warranty.

B. Fasteners: Where fasteners are to be embedded in masonry or the structural system, they shall be coordinated to insure installation at the proper time of construction.

C. Certification: Upon completion of the installation the Contractor shall provide to the owner the Master Label issued by Underwriters Laboratories, Inc. for the installation, and the LPI certification issued by LPI.

END OF SECTION 264113

SECTION 264313

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 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 Current Technology, Advance Protection, Leviton

2.2 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.

2.3 SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

A. SPDs: Comply with UL 1449, Type 1.

B. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 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 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 208Y/120 V.
3. Line to Line: 1000 V for 208Y/120 V.

E. SCCR: Equal or exceed 100 kA.

F. Inominal Rating: 20 kA.

2.4 PANEL SUPPRESSORS

A. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

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. 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: 700 V for 208Y/120 V.
2. Line to Ground: 700 V for 208Y/120 V.
3. Neutral to Ground: 700 V for 208Y/120 V.
4. Line to Line: 1200 V for 208Y/120 V

D. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

E. SCCR: Equal or exceed 100 kA.

F. Inominal Rating: 20 kA.

2.5 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. 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.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Complete startup checks according to manufacturer's written instructions. Energize SPDs after power system has been energized, stabilized, and tested.

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 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265116

FLUORESCENT INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior fluorescent luminaires, lamps, and ballasts.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260943"Network Lighting Controls".

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

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.

1.4 INFORMATIONAL SUBMITTALS

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

B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled luminaires, from manufacturer.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 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 for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598.

D. Nominal Operating Voltage: 120 V ac.

E. Recessed Luminaires: Comply with NEMA LE 4.

2.2 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.

3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
4. Sound Rating: Class A.
5. THD Rating: Less than 10 percent.
6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
7. Operating Frequency: 42 kHz or higher.

B. Electromagnetic Ballasts: Comply with ANSI C82.11; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.

1. Ballast Manufacturer Certification: Indicated by label.

C. Single Ballasts for Multiple Luminaires: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

D. Ballasts for Residential Applications: Luminaires designated as "residential" may use low-power-factor electronic ballasts having a Class B sound rating and THD of approximately 30 percent.

E. Ballasts for Dimmer-Controlled Luminaires: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

F. Ballasts for Bi-Level Controlled Luminaires: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level operation and off.

   a. High-Level Operation: 100 percent of rated lamp lumens.
   b. Low-Level Operation: 30 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

G. Ballasts for Tri-Level Controlled Luminaires: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level operation and off.

   a. High-Level Operation: 100 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.

3. Compatibility: Certified by manufacturer for use with specific tri-level control system and lamp type indicated.

2.3 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Sound Rating: Class A.
3. THD Rating: Less than 20 percent.
4. Operating Frequency: 20 kHz or higher.
5. BF: 0.95 or higher unless otherwise indicated.
6. Power Factor: 0.95 or higher.
7. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on EMI and RFI for nonconsumer equipment.

2.4 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Remote Test: Switch in hand-held 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.
3. 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.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from luminaire. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Remote Test: Switch in hand-held 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.

3. 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.

2.5 FLUORESCENT LAMPS

A. T8 rapid-start lamps, rated 32-W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

B. T8 rapid-start lamps, rated 17-W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

C. Compact Fluorescent Lamps: Four-pin, CRI of 80 (minimum), color temperature of 3500 K, average rated life of 10,000 hours at three hours of operation per start, and suitable for use with dimming ballasts unless otherwise indicated.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.6 CYLINDER

A. With integral mounting provisions.

2.7 DOWNLIGHT

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.8 RECESSED LINEAR

A. Integral junction box with conduit fittings.

2.9 STRIP LIGHT

A. Integral junction box with conduit fittings.

2.10 SURFACE MOUNT, LINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.11 SURFACE MOUNT, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.12 SUSPENDED, LINEAR

A. Ceiling mounted with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.

2.13 SUSPENDED, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.14 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. 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. clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: One hundred 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. powder-coat painted finish.

2.15 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.

2.16 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. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.

C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Remote Mounting of Ballasts: Distance between the ballast and luminaire shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

C. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

D. Install lamps in each luminaire.

E. Supports: Sized and rated for luminaire weight.

F. Ceiling-Grid-Mounted Luminaire Supports:

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches from luminaire corners.
2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

G. Flush-Mounted Luminaire Support:

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.

H. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

I. 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 tubing or rod 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.

J. 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.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 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.

END OF SECTION 265116

SECTION 265119

LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260943 "Network Lighting Control " for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

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. LEED Submittals:

1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

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

B. Product Certificates: For each type of luminaire.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 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 for hazardous locations 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. Recessed Fixtures: Comply with NEMA LE 4.

E. CRI of 80. CCT of 3000 K.

F. Rated lamp life of 50,000 hours.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. Nominal Operating Voltage: 120 V ac.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

J. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized finish.

2.2 CYLINDER

A. With integral mounting provisions.

2.3 DOWNLIGHT

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.4 RECESSED LINEAR

A. Integral junction box with conduit fittings.

2.5 STRIP LIGHT

A. Integral junction box with conduit fittings.

2.6 SURFACE MOUNT, LINEAR

A. Integral junction box with conduit fittings.

2.7 SURFACE MOUNT, NONLINEAR

A. Integral junction box with conduit fittings.

2.8 SUSPENDED, LINEAR

2.9 SUSPENDED, NONLINEAR

A. Integral junction box with conduit fittings.

2.10 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. 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. Tempered Fresnel glass prismatic glass diffuse glass clear glass prismatic acrylic clear, UV-stabilized acrylic
2. Acrylic: 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.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear Insert color anodized powder-coat painted finish.

2.11 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.

2.12 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. Single-Stem Hangers: 1/2-inch steel tubing with 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: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 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: Sized and rated for luminaire weight.

E. Flush-Mounted Luminaire Support: Secured to outlet box.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:

1. Ceiling mount per manufacturer's approved shop drawings.

H. 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 tubing or rod 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.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 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.

END OF SECTION 265119

SECTION 265219

EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with integral or remote 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support, arranged by designation.

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.

1.4 INFORMATIONAL SUBMITTALS

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

B. Product Certificates: For each type of luminaire.

C. Sample Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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 recessed luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
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. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet.
    .

4. Test Push-Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, nickel-cadmium type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. 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.

G. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
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 fixture continuously.
4. Battery: Sealed, maintenance-free, nickel-cadmium 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 ballast 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. 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 Luminaires:

1. Emergency Luminaires: as indicated on Drawings, with the following additional features:

   a. Operating at nominal voltage of 120 V ac.
   b. Internal emergency power unit.
   c. Rated for installation in damp locations, and for sealed and gasketed fixtures in wet locations.
   d. UL 94 flame rating.

C. Emergency Lighting Unit:

1. Emergency Lighting Unit: as indicated on Drawings.
2. Operating at nominal voltage of 120 V ac.
3. Wall with universal junction box adaptor.
4. UV stable thermoplastic housing, rated for damp locations.
5. Two LED lamp heads.
6. Internal emergency power unit.
7. External emergency power unit.

2.4 EXIT SIGNS

A. Internally Lighted Signs:

1. Operating at nominal voltage of 120 V ac.

2. Lamps for AC Operation: Fluorescent, two for each fixture; 20,000 hours of rated lamp life.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

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. Tempered Fresnel glass Prismatic glass Diffuse glass Clear glass Prismatic acrylic Clear, UV-stabilized 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 Insert option housing and heat sink.
2. anodized powder coat painted finish.

E. Conduit: , 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.

PART 3 - EXECUTION

3.1 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 and emergency power unit 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 fixture weight.

E. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach fixtures 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 Fixtures: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of fixture 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 tubing or rod for suspension for each unit length of fixture 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.

H. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 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.

END OF SECTION 265219

SECTION 265600

EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

1.2 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.

C. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1.3 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Anchor-bolt templates keyed to specific poles and certified by manufacturer.

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. Comply with IEEE C2, "National Electrical Safety Code."

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
2. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. 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. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. 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.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. 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.

M. 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, "Solvent Cleaning," 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, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
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.
   b. Color: Match Architect's sample of [**manufacturer's standard**] [**custom**] color.
   c. Color: As selected by Architect from manufacturer's full range.

N. 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; 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.

O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. 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 and ballast characteristics:

a. "USES ONLY" and include specific lamp type.
b. Lamp tube configuration (twin, quad, triple), base type, and nominal wattage for compact fluorescent luminaires.
c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
d. Start type (preheat, rapid start, instant start) compact fluorescent luminaires.
e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
f. CCT and CRI for all luminaires.

2.3 FLUORESCENT BALLASTS AND LAMPS

A. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F and Higher: Electronic type rated for 0 deg F starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.

B. Ballast Characteristics:

1. Power Factor: 90 percent, minimum.
2. Sound Rating: Class A.
3. Total Harmonic Distortion Rating: Less than 20 percent.
4. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
5. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
6. Transient-Voltage Protection: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F and higher.

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F.
3. Normal Ambient Operating Temperature: 104 deg F.
4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

2.5 HID LAMPS

A. .

A. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and CCT color temperature 4000 K.

B. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and CCT color temperature 4000 K.

2.6 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.7 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.
   1. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Brackets for Luminaires: Detachable, cantilever, without underbrace.

   1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with-steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
   3. Match pole material and finish.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.

E. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

F. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

G. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

H. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

I. Factory-Painted Finish: 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, "Solvent Cleaning," 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, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As indicated by manufacturer's designations.

2.8 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
1. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

F. Aluminum Finish: 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; 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.

2.9 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches.
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch-diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 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.

3.6 GROUNDING

A. Ground metal poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

END OF SECTION 265600

SECTION 27 0100

GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 27.

B. This section is a Division 27 COMMUNICATIONS section, and is a part of each Division 27 Section.

C. Requirements of the following Division 27 Sections apply to this section:

1. Division 27 section 27 0500 "Common Work Results for Communications".

1.2 SUMMARY

A. This section includes the General Requirements for providing an acceptable response to this RFP. These requirements are in addition to the Division 1 specification sections.

B. The proposal must provide for a complete, functional and tested cable infrastructure system inclusive of all labor and materials.

C. The desired solution should include an extended warranty that protects the Owner from manufacturer or installation defects. This Specification and the associated drawing set provide for the Intent of the system and are not intended to represent a complete or end-to-end system.

1.3 SCHEDULE

A. Per the general contractors Construction Schedule

1.4 SITE ADDRESS

Key West City Hall
1300 White St.
Key West, Florida

1.5 STANDARDS ADHERENCE

A. All work shall be installed according to the following industry standards guidelines.
B. ANSI/TIA/EIA – 568-B.1 Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
C. ANSI/TIA/EIA – 568-B.2 –Commercial Building Telecommunications Cabling Standard, Part 2: 100 Ohm Balanced Twisted-Pair Cabling
D. ANSI/TIA/EIA–568-B.3 – Optical Fiber Cabling Components Standard
E. ANSI/TIA/EIA-569-A-1 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 1 - Surface Raceways (April 2000).

F. ANSI/TIA/EIA-569-A-2 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 2 - Furniture Pathways and Spaces (April 2000).
G. ANSI/TIA/EIA-569-A-3 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 3 – Access Floors (March 2000).
H. ANSI/TIA/EIA-569-A-4 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 4 – Poke – Thru Fittings (April 2000).
I. ANSI/TIA/EIA-569-A-5 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 5 – In Floor Systems (June 2001).
J. ANSI/TIA/EIA – 606-A – The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
K. ANSI/TIA/EIA – 607 - Commercial Building Grounding and Bonding Requirements for Telecommunications
L. ANSI/TIA/EIA – 758 – Customer Owned Outside Plant
M. ANSI/TIA/EIA-758 - 1 Customer Owned Outside Plant Telecommunications Cabling Standard, Addendum 1
N. EEE Emerald Book - Recommended Practice for Powering and Grounding Electronic Equipment
O. ISO/IEC 11801
P. BICSI Telecommunications Distribution Methods Manual (TDMM), Revision 10, 2003.
Q. American National Standards Institute (ANSI).
R. American Society of Testing and Materials (ASTM).
S. Building Industry Consulting Service International (BICSI).
T. Electronics Industries Alliance (EIA).
U. Telecommunications Industries Association (TIA).
V. Federal Communications Commission (FCC).
W. Institute of Electrical and Electronic Engineers (IEEE).
X. National Electrical Code (NEC), NFPA 70, 2008 Edition.
Y. National Electrical Manufacturer's Association (NEMA).
Z. National Fire Protection Association (NFPA).
AA. Underwriters Laboratories (UL).
BB. Any and all requirements of the local Authority Having Jurisdiction (AHJ).

1.6 The Contractor and all installation technicians shall be certified by the Manufacturer to install
1. the cable infrastructure system

1.7 DEFINITIONS

A. PROVIDE means to furnish, place, erect, connect, test and turn over to Owner, complete and ready for the regular operation, the particular work referred to.

B. INSTALL means to join, unite, fasten, link, attach, set up or otherwise connect together before testing and turning over to Owner, complete and ready for regular operation, the particular work referred to.

C. FURNISH means to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories and all other items customarily required for the proper and complete application for the particular work referred to.

D. WIRING means the inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such work.

E. CONDUIT means the inclusion of all fittings, hangers, supports, sleeves, etc.

F. AS DIRECTED means as directed by the Architect or their representative.

G. CONCEALED means embedded in masonry or other construction, installed behind wall furring or within double partitions or installed within hung ceilings.

H. ACCEPTED means as accepted by the Architect or their representative.

I. APPROVED means as approved by the Architect or their representative.

J. EQUAL means equivalent as approved by the Architect or their representative.

K. CONTRACTOR as stated herein shall mean Communication Contractor.

1.8 SUBMITTALS

A. General: Follow the procedures specified in Division 1 and as stated below.

1. The Contractor shall submit a complete set of Project Documents and complete product data for the proposed system to the system vender for review prior to submission to the Architect/Engineer. The System Vender shall review the complete system package and provide documentation attesting to the system compliance with the extended system product and performance warranty. This documentation must accompany all submittals to the Architect/Engineer. Submittals will not be reviewed by the Architect/Engineer without the System Vender approval documentation.

2. Submit for approval a complete Material Source of Supply and Subcontractor list for all work required under this project. Shop drawing submittals will not be reviewed until a complete Material Source of Supply and Subcontractor list is received.

3. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect, will not be processed.

4. Prepare and submit detailed shop drawings for materials, systems, and equipment as listed herein, including locations and sizes of all required openings in floor decks, walls and floors.

5. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.

6. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and re-submittal as may be required. All submittals shall be complete and contain all required and detailed information.

7. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing all items of proper dimensions, weight, capacities, sizes, quantity and quality as intended by the Contract. Such acceptance shall not relieve the Contractor from responsibility for errors, omissions, or inadequacies of any sort on submitted data or shop drawings.

8. Each shop drawing shall contain job title and reference to the applicable drawing and specification article, including the Contractor's drawings, specifications, and verification of compatibility with the systems involved.

9. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be return without review.

10. All nameplate data shall be complete at time of equipment submittals - refer to other sections for identification requirements.

11. For each room or area of the building containing sound system cabinets, telephone backboards, consoles, etc., coordination drawings are required to be submitted for review and acceptance at the time of the equipment submittal.

12. Equipment shall not be purchased until the shop drawing approval is received.

13. Shop Drawings shall show conformance with specified equipment characteristics, or Contractor shall assume responsibility for all deviations including all additional costs involved for the deviations.

14. Submittals shall include plan, riser and wiring diagrams complete with all wiring and required equipment.

1.9 PRODUCT OPTIONS

A. The product manufacturers listed in each section are either the product the design is based on or a product that the Engineer feels would be an acceptable substitution if that product can meet the intent of the written specifications and the scheduled capacities. The Communication Contractor is responsible for ensuring that the substituted product complies with the intent of the specifications, the scheduled capacities and the drawings. Substitutions of manufacturers not listed are not permitted unless prior approval is obtained from the Engineer.

B. It will be the responsibility of the Communication Contractor to pay any and all costs associated with any approved substitutions that impact the architectural layout, structure, electrical system(s), mechanical systems, and/or the plumbing systems, due to an increase in physical dimensions, weight, electrical requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.

C. In order for the manufacturer to certify this local area network cabling system, the system components must meet the requirements of the manufacturer. Review the system with the manufacturer in accordance with their system certification program and provide a letter from the manufacturer documenting the following;

D. That the Contractor is a manufacturer certified installer.
E. That all the materials in the submittal are in accordance with the manufacturer's certification program.
F. That the manufacturer has reviewed the entire system in accordance with their certification program and the system is in compliance.
G. A system that does not have a manufacturer's certification will not be accepted.

1.10 COOPERATION AND COORDINATION WITH OTHER TRADES

A. This Contractor shall cooperate completely and coordinate work with the contractors of other trades. Due to the Project Schedule this Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.

B. Prepare floor plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Specific equipment installations, including, but not limited to racks for LAN equipment, racks for sound system equipment, cable television equipment, etc.
2. Where additional conduit sleeves are required in order to limit UTP cable length to 90 meters.
3. Wiring diagrams: Indicating field installed communication wiring and cabling layouts, equipment, and equipment connections.

PART 2 PRODUCTS

2.1 Major items of equipment shall have manufacturer's name, address and catalog number on a plate securely attached in a convenient place. All equipment or apparatus of any one system must be the product of one manufacturer, or approved equivalent products of a number of manufacturer's that are suitable for use in a unified system.

2.2 All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.

2.3 In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.

2.4 All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units, and shall be furnished as such.

2.5 In certain instances specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.

2.6 Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.

2.7 Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Design Consultant.

2.8 Where the contractor proposes substitute equipment he shall submit acceptable evidence to indicate compliance with all requirements of the documents, including performance rating, equivalent to the specified item. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.

2.9 All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data, or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.

PART 3 EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

C. Coordinate deliveries of materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

3.2 SEQUENCE OF WORK

A. Construct work in a sequence in accordance with Division 1.

B. Due to current Project Schedule the Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.

3.3 INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of

construction, to allow for installations of cabling. Arrange such chases, slots and openings such that UTP cable does not exceed 90 meters.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

B. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

1. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
2. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
3. Coordinate the cutting and patching of building components to accommodate installation of equipment and materials.
4. Coordinate the installation of materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.
5. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.

3.4 CLEANING

A. Refer to the Division 1 Section for general requirements for final cleaning.

3.5 TESTING

A. Contractor, at his own expense, shall make any and all tests directed by an inspection authority, or connector manufacturer, or the Architect, and shall provide all equipment, instruments and materials to make such tests.

B. Unless otherwise approved, all terminations shall be made and all components shall be in place, complete and operational, at time of final inspection and tests.

C. Time of such tests, the manner in which they are made and the results of the tests, shall be subject to approval.

D. Upon completion of work, all component parts, both singularly and as a whole, shall be set, calibrated, adjusted and left in satisfactory operating condition to suit load conditions, by means of instruments furnished by the Contractor.

E. Complete testing of equipment and systems shall be provided throughout this project.

F. Industry standards shall apply except as otherwise specified.

G. Provide all labor, premium labor and materials required by field-testing as specified in the Contract Documents and as required.

H. Notify the Architect seven (7) days prior to the testing dates. Upon completion of a test, a statement of certification shall be forwarded to the Architect for his approval.

I. Conduct tests at a time agreeable to the Architect. Provide premium labor as necessary.

J. Products that are found defective or do not pass such tests shall be removed and replaced at the Contractor's expense. Tests shall be repeated.

3.6 INSTRUCTIONS TO THE OWNER

A. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.

B. Additional instruction requirements are included in each section of the Specifications.

C. The Contractor shall video tape all instruction sessions. Prepare a separate video tape for each system. Clearly label the tape with the title “INSTRUCTIONS FOR THE USE OF” on both the face and the spine, in typewritten letters. Two (2) copies of each video tape shall be given to the Owner at the completion of the Contract; one (1) set for the maintenance staff and one (1) set for the administrative staff.

D. Prepare an instructional training form indicating the topic of instruction, the date, the time, the purpose of instruction and lines for signatures of attendees. Each person attending the instruction shall print their name and sign the form. Provide a copy of the completed form to the Owner in the O&M manual as proof of instructional training. The Contractor shall keep the original in the Contractor’s project file.

END OF SECTION 27 0100

SECTION 27 0103

COMMUNICATIONS SYSTEMS WARRANTIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Provide complete documented Contractor, Installation, Performance and Manufacturer's warranties and guarantees as indicated on the Drawings, Specified or as otherwise required.

PART 2 GENERAL

2.1 CONTRACTOR GUARANTEE

A. The Contractor shall guarantee the installation to be free from inherent defects in installation, workmanship and material. The installation shall function properly and continuously under all operating conditions required, specified or reasonably implied in the contract documents. The Contractor shall replace, at no expense to the Owner, all equipment, materials or any component thereof, found defective, within two (2) years from date of final inspection and written acceptance by the Owner and Engineer.

B. The Contractor shall provide for a manufacturers certified and warranted installation with an extended guarantee. The warranty shall be based fully upon the design criteria contained herein, meeting all specifications and standards for installation and materials. The warranty shall include shop drawings and cut sheets on all equipment and materials, documentation verifying the Contractors certification by the manufacturer, details of the manufacturer's certification program, and full details of the extended warranty.

2.2 CONTRACTOR SUBMITTALS

A. Submit Commscope Uniprise Warrantee prior to IT Department acceptance of the Commscope Uniprise Structured Connectivity Solution.

B. The Contractor shall forward all completed and implemented manufacturer's warranties and guarantees, and supporting documents, on equipment and materials not covered by the Commscope Uniprise Warranty.

2.3 EQUIPMENT AND MATERIALS WARRANTY

A. All equipment and material manufacturers shall replace, at no expense to the Owner, all equipment and materials or any component thereof, found defective within the manufacturers standard warranty period or one year minimum from date of final inspection and written acceptance by the Owner. The equipment and/or material manufacturer shall provide a written warranty document.

B. Primary responsibility for initiating and implementing the manufacturer's warranty shall be the installing contractor under his guarantee.

2.4 STRUCTURED CONNECTIVITY SOLUTION EXTENDED PRODUCT WARRANTY AND APPLICATION ASSURANCE PROGRAM

A. The following warranty verbiage applies only to Commscope Uniprise Structured Connectivity Solution (SCS) products purchased and used in the United States of America and registered with Commscope Uniprise as evidenced by a numbered Registration Certificate issued by Commscope Uniprise. The Commscope Uniprise SCS installation must be comprised entirely of a Commscope Uniprise SCS certified end-to end channel of products and installed by a certified Commscope Uniprise Reseller.

2.5 Extended Product Warranty

A. The extended product warranty covers product defects for all passive Commscope Uniprise manufactured Commscope Uniprise components. Passive components are defined as those exhibiting no gain or contributing no energy. Commscope Uniprise warrants, from the original installation completion date, provided a registration Certificate is issued by Commscope Uniprise to the end-user, the following:
   1. That the passive products that comprise the registered Commscope Uniprise solution will be free from manufacturing defects in material or workmanship under normal and proper use.
   2. That all Commscope Uniprise approved passive cabling products that comprise the registered Commscope Uniprise solution meet or exceed the relevant component specification of the TIA 568-B Series and ISO/IEC 11801: 2002.
   3. That the Registered COMMSCOPE UNIPRISE SCS compliant PowerSum, GigaSPEED X10D, GigaSPEED XL7, GigaSPEED XL8, OptiSPEED, LazrSPEED, and or TeraSPEED links/channels will meet or exceed the applicable requirements of the TIA 568B Series, and ISO/IEC 11801: 2002 standards for cabling links/channel configurations specified in these standards.
   4. That the Registered COMMSCOPE UNIPRISE SCS compliant PowerSum, GigaSPEED X10D, GigaSPEED XL7, GigaSPEED XL8™ channels will additionally meet or exceed the Guaranteed Channel Performance in the COMMSCOPE UNIPRISE SCS Performance Specification Addendum in effect at the time of installation.
B. This extended Product Warranty is applicable to the Commscope Uniprise SCS only on the original site of installation. Under the Extended Product Warranty, Commscope Uniprise will either repair or replace the defective product itself (or will authorize a COMMSCOPE UNIPRISE Business Partner to) at Commscope Uniprise cost. And in the U.S.A. Commscope Uniprise will pay an authorized reseller for the cost of labor to repair or replace any such defective product on behalf of Commscope Uniprise.

2.6 Application Assurance

A. Application Assurance covers failure of the Commscope Uniprise SCS to operate the applications which the system was designed to support, as well as additional application(s) defined below. Commscope Uniprise warrants that the registered Commscope Uniprise SCS solution will be free from defects which prevent operation of the specific applications for which the original Commscope Uniprise SCS was designed as long as the design was in conformance with the COMMSCOPE UNIPRISE SCS Performance Spec for said applications and is in compliance of all other terms and conditions of the warranty.
B. The Application Assurance Program also covers the following additional applications:
   1. Those identified in the current (at the time of installation) Commscope Uniprise SCS Performance Specifications; and in accordance with application standards specifications, any

applications introduced in the future by recognized standards or user forums that use TIA/EIA 568B or ISO/IEC 11801 2nd Additions

2. (September 2002) components and link/channel specifications for cabling, to the extent that such applications are defined to operate over the guaranteed channel performance and/or the installed channel topologies.

2.7 Term of Warranty

A. For twenty (20) years from the date of issuance of the Registration Certificate or installation, whichever is earlier.

2.8 Persons / Entity Covered

A. This Limited Warranty shall be for the benefit of the person or entity to whom the Commscope Uniprise Registration Certificate is issued and any successor (Transferable) in interest to the site in which such system was originally installed by Commscope Uniprise or an authorized Commscope Uniprise Reseller.

2.9 If Commscope Uniprise repairs the product, it may use new or reconditioned replacement parts. If Commscope Uniprise chooses to replace the product, Commscope Uniprise may replace it with a new or reconditioned one of the same or similar design. Any such repair or replacement will be warranted for either (a) 90 days or (b) the remainder of the original 20-year warranty period, whichever is longer.

PART 3 EXECUTION

3.1 IMPLEMENTATION

A. The Contractor shall provide a Letter of Guarantee for a period of two (2) years on Company Letterhead, dated and signed by the Contractor Representative.
   1. In the event that the Installing Contractor is a Subcontractor to the Primary Contractor, both contractors shall provide a Letter of Guarantee, acknowledging and accepting responsibility and liability for the others installation and performance under Division 27 Specifications in the event of default by the other.

3.2 The Contractor shall be responsible for the coordination and implementation of all equipment and material manufacturer's guarantees and warranties.

   1. The Contractor shall provide copies of all guarantees and warranties which shall be signed and dated by the manufacturer's representative.
   2. All completed warranty and guarantee documents shall be provided with the close out documentation,

END SECTION 27 0103

SECTION 27 0500

COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 27 Sections apply to this section:

1. Division 27 Section 27 0100 “Basic Communication System Requirements”.

1.2 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with electrical installations as follows:

PART 2 PRODUCTS

2.1 Major items of equipment shall have manufacturer's name, address and catalog number on a plate securely attached in a convenient place. All equipment or apparatus of any one system must be the product of one manufacturer, or approved equivalent products of a number of manufacturer's that are suitable for use in a unified system.

2.2 All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.

2.3 In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.

2.4 All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units, and shall be furnished as such.

2.5 In certain instances specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.

2.6 Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.

2.7 Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Project Consultant.

2.8 Where the contractor proposes substitute equipment he shall submit acceptable evidence to

indicate compliance with all requirements of the documents, including performance rating, equivalent to the specified item. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.

2.9 All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data, or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.

2.10 FIRESTOPPING

A. Use only that manufacturer listed in UL Fire Resistance Directory for the UL system involved.

B. All fire stopping materials used on this project shall be the products of one manufacturer. Each trade shall use products of the same manufacturer.

C. Standards: The fire stop systems and products shall have been tested in accordance with the procedures of

D. U.L. 1479 (ASTM E814-81) and material shall be UL classified as Fill, Void or Cavity Materials for use in Through-Penetration Fire stops. The fire stop system shall comply with NEC Paragraph 300-21. All work shall comply with NFPA 101-Life Safety Code, Latest Edition.

2.11 FIRE-RATED WALL PENETRATIONS

A. Description: Manufactured fire rated pathways and sleeves, designed for field assembly, to restore original fire-resistance rating of floor and wall while allowing the ability to freely install or remove cabling without affecting the fire rating of device.

B. HILTI 653 speed sleeve – as specified on the "T" series drawings

C. Reference Section 270637 or Section 078400 for additional information regarding fire-rated wall penetrations.

PART 3 EXECUTION

3.1 GENERAL

A. All construction under this contract shall be completed in a neat and craftsman like manner. Work that, in the judgment of the Architect, is not satisfactorily installed shall be removed and replaced to the Architect's satisfaction, at the Contractor's expense.

B. Housekeeping: Throughout construction, all work areas and storage areas shall be kept clean. The Contractor shall keep all items clean of dirt, rust, dust and finger marks.

3.2 FIRESTOPPING

A. Where communication conduits, conduit sleeves, wire ways, and other raceways or cables pass

through fire partitions, fire walls, fire floors, or smoke walls, the Contractor shall provide a fire or smoke stopping that provides an effective barrier against the spread of fire, smoke or gases.

B. Installation of Fire-Stopping Materials: Install materials to fill openings around services penetrating floors and walls and provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Install materials in accordance with printed instructions of the UL Fire Resistance Directory and per manufacturer's published instructions.

C. All cables that are installed in conduit sleeves or in wire ways through fire or smoke floors or partitions shall be provided with an equally rated re-enterable U.L. listed fire and smoke rated putty in the opening.

D. Examine fire/smoke-stopped areas to ensure proper installation before concealing or enclosing areas.

E. Keep areas of work accessible until inspection by applicable code authorities.

3.3 LOCATIONS

A. Obtain written approval of locations of all devices from the Owner and Architect prior to rough- in/installation. The owner reserves the right to move any or all communication devices prior to installation, at no additional cost.

B. Contractor shall obtain detailed and specific information regarding location of all equipment. Final locations may differ from those indicated on Drawings. Work improperly placed because of Contractor's failure to obtain this information shall be relocated and reinstalled as directed, without additional costs to the Contract.

C. The design shall be subject to such revisions as may be necessary to overcome building obstructions. No changes shall be made in location of equipment without prior written approval.

END OF SECTION 27 0500

SECTION 27 526
GROUNDING

PART 1 GENERAL

1.1 DESCRIPTION

A. This section specifies general grounding and bonding requirements of electrical and telecommunication installations for personnel safety, equipment operations and to provide a low impedance path for possible ground fault currents.

B. "Grounding electrode system" refers to all electrodes required by NEC, as well as including made, supplementary, lightning protection system and telecommunications system grounding electrodes.

C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

D. The Ground Bonding Backbone for Telecommunications Systems and the Ground Bus Bar in Telecommunications Spaces shall be provided and installed by the Electrical Contractor.

1.2 RELATED WORK

A. Section 27 1100: Communications Equipment Room Fittings and Grounding

B. Section 27 0529: Hangers and Supports for Communication Systems

C. Section 27 0534: Boxes and Fittings

D. Section 27 0528: Cable Tray

1.3 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification.

1. American Society for Testing and Materials (ASTM):
   a. B1-2001: Standard Specification for Hard-Drawn Copper Wire
   b. B8-2004: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

   a. 81-1983: IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

3. National Fire Protection Association (NFPA):

   a. 70-08: National Electrical Code (NEC)

4. Telecommunications Industry Association, (TIA)

    a. J-STO-607-A-2002: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

5. Underwriters Laboratories, Inc. (UL):

    a. 44-2005: Thermoset-Insulated Wires and Cables
    b. 83-2003: Thermoplastic-Insulated Wires and Cables
    c. 467-2004: Grounding and Bonding Equipment
    d. 486A-486B-2003: Wire Connectors

PART 2 PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes 25 mm² (4 AWG) and larger shall be permitted to be identified per NEC.

B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be ASTM B1 solid bare copper wire.

C. Telecom System Grounding Riser Conductor: Telecommunications Grounding Riser shall be in accordance with J STO-607A. Use a minimum (2 AWG) insulated stranded copper grounding conductor unless indicated otherwise.

2.2 SPLICES AND TERMINATION COMPONENTS

A. Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.3 TELECOMMUNICATION SYSTEM GROUND BUSBARS

A. The Electrical Contractor shall Provide and Install a solid copper bus bar, pre-drilled from two-hole lug connections with a minimum thickness of 6 mm (1/4 inch) for wall and backboard mounting using standard insulators sized as follows:

    1. IDF Room Signal Grounding: 300 mm x 100 mm (12 inches x 4 inch).
    2. MDF Signal Ground: 600 mm x 100 mm (24 inches x 4 inch).

2.4 GROUND CONNECTIONS

A. Below Grade: Exothermic-welded type connectors.

B. Above Grade:

1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lock washers.
2. Ground Bus bars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.
3. Rack and Cabinet Ground Bars: one-hole compression-type lugs using zinc-plated or copper alloy fasteners.

C. Cable Shields: Make ground connections to multi-pair communications cables with metallic shields using shield bonding connectors with screw stud connection.

2.5 GROUND TERMINAL BLOCKS

A. At any equipment mounting location (e.g. backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.6 LIGHTNING ARRESTORS

A. Lightning protectors shall be supplied on all OSP cables as specified by the manufacturer. At minimum, use 16 mm² (6 AWG) insulated ground wire with shield bonding connectors.

PART 3 EXECUTION

3.1 GENERAL

A. Ground Bonding Backbone and Bus Bars in all cases are to be provided and installed by the Electrical Contractor. Ground Bonding conductors from equipment included in the Low Voltage Contractors Scope shall be provided and installed by the low voltage Contractor.

B. Ground in accordance with the NEC, as shown on drawings, and as hereinafter specified.

C. System Grounding:

D. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

A. Make grounding connections, which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.

3.3 CORROSION INHIBITORS

A. When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces.
B. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.4 COMMUNICATION ROOM GROUNDING

A. Telecommunications Ground Bus bars:

B. Electrical Contractor to Provide and install communications room IDF/MDF/IDF telecommunications ground bus bar hardware at locations indicated on the Drawings.

C. Backboards are to be provided and installed by the General Contractor: Provide a screw lug-type terminal block or drilled and tapped copper strip near the top of backboards used for communications cross-connect systems. Connect backboard ground terminals to the aluminum pan in the telephone-type cable tray using an insulated 16 mm² (16 AWG) bonding jumper.

D. Other Communication Room Ground Systems: Ground all metallic conduit, wire ways, and other metallic equipment located away from equipment racks or cabinets to the cable tray pan or the telecommunications ground bus bar, whichever is closer, using insulated 16 mm² (6 AWG) ground wire bonding jumpers.

3.5 COMMUNICATIONS CABLE GROUNDING

A. Bond all metallic cable sheaths in multi-pair communications cables together at each splicing and/or terminating location to provide 100 percent metallic sheath continuity throughout the communications distribution system.

1. At terminal points, install a cable shield bonding connector provide a screw stud connection for ground wire. Use a bonding jumper to connect the cable shield connector to an appropriate ground source like the rack or cabinet ground bar.
2. Bond all metallic cable shields together within splice closures using cable shield bonding connectors or the splice case grounding and bonding accessories provided by the splice case manufacturer. When an external ground connection is provided as part of splice closure, connect to an approved ground source and all other metallic components and equipment at that location.

3.6 COMMUNICATIONS CABLE TRAY SYSTEMS

A. Bond the metallic structures of one cable tray in each tray run following the same path to provide 100 percent electrical continuity throughout this cable tray systems as follows:

1. Splice plates provided by the cable tray manufacturer can be used for providing a ground bonding connection between cable tray sections when the resistance across a bolted connection is 10 milliohms or less. The contractor shall verify this loss by testing across one slice plate connection in the presence of the Engineer.
2. Install a 16 mm² (6 AWG) bonding jumper across each cable tray splice or junction where splice plates cannot be used.
3. When cable tray terminations to cable rack, install 16 mm² (6 AWG) bonding jumper between cable tray and cable rank pan.

3.7 WIREWAY GROUNDING

A. Ground and Bond Metallic Wire way Systems as follows:

1. Bond the metallic structures of wire way to provide 100 percent electrical continuity

throughout the wire way system by connecting a 16 mm² (6 AWG) bonding jumper at all intermediate metallic enclosures and across all section junctions.

2. Install insulated 16 mm² (6 AWG) bonding jumpers between the wire way system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 16 meters (50 feet).
3. Use insulated 16 mm² (6 AWG) bonding jumpers to ground or bond metallic wire way at each end at all intermediate metallic enclosures and cross all section junctions.
4. Use insulated 16 mm² (6 AWG) bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 meters.

3.8 COMMUNCIATIONS RACEWAY GROUNDING

A. Cable Tray Systems: Use insulated 16 mm² (6 AWG) bonding jumpers to ground cable tray per manufacturer specifications.

3.9 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Government. Final tests shall assure that this requirement is met.

B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

C. Services at power company interface points shall comply with the power company ground resistance requirements.

D. Below-grade connections shall be visually inspected by the Resident Engineer prior to backfilling. The Contractor shall notify the Resident Engineer 24 hours before the connections are ready for inspection.

END OF SECTION 27 0526

SECTION 27 0529

HANGERS AND SUPPORTS FOR COMMUNCATION SYSTEMS

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 Requirements of the following Division 27 Sections apply to this section:

A. Division 27 Section 27 0100: "Basic Communication Systems Requirements".
B. Division 27 Section 27 0500: "Common Work Results for Communications".

1.3 SUMMARY

A. This Section includes secure support from the building structure for communication items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

B. All supports shall utilize threaded fasteners for all connections/attachments. The use of clips or clip-on type supports is not acceptable.

C. Types of supports, anchors, sleeves, and seals specified in this section include the following:

1. Clevis hangers
2. Riser clamps
3. C-clamps
4. I-beam clamps
5. Conduit straps
6. Round steel rods
7. Lead expansion anchors
8. Toggle bolts
9. Wall and floor seals

1.4 Supports, anchors, sleeves, and seals furnished as part of factory-fabricated equipment, are specified as part of that equipment assembly in other Division-27 sections.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01

Specification Sections.

B. Product Data: Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

C. Shop Drawings: Submit dimensioned drawings of fabricated products, indicating details of fabrication and materials.

1.6 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of supporting devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing supporting device work similar to that required for this project.

C. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of supporting devices.

D. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.

E. UL Compliance: Provide components that are UL listed and labeled.

F. FS Compliance: Comply with Federal Specification FF-S-760 pertaining to retaining straps for conduit, pipe, and cable.

G. Components shall be listed and labeled by ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

B. Slotted Metal Angle and U-Channel Systems:

1. Allied Tube & Conduit
2. American Electric
3. B-Line Systems, Inc.
4. Cinch Clamp Company, Inc.
5. Elcen Metal Products Company
6. Greenfield Mfg. Company, Inc.
7. Haydon Corporation

8. Kin-Line, Inc.
9. Midland-Ross Corporation
10. Power-Strut Div; Van Huffel Tube Corporation
11. Unistrut Diversified Products

C. Anchors:

1. Abbeon Cal Inc.
2. Ackerman Johnson Fastening Systems Inc.
3. Elcen Metal Products Company
4. Ideal Industries, Inc.
5. Joslyn Mfg. and Supply Company
6. McGraw Edison Company
7. Rawl Plug Company Inc.
8. Star Expansion Company
9. U.S. Expansion Bolt Company
10. Hilti, Inc.

2.2 U-CHANNEL STRUT SYSTEMS

A. Provide U-channel strut system for supporting communication equipment, 12-gage hot-dip galvanized steel, of types and sizes indicated; construct with 9/16" diameter holes, 8" o.c. on top surface, with standard green finish, and with the following fittings which mate and match with U-channel and are of the same manufacturer:

1. Fixture hangers
2. Channel hangers
3. End caps
4. Beam clamps
5. Wiring stud
6. Thin wall conduit clamps
7. Rigid conduit clamps
8. Conduit hangers
9. U-bolts

2.3 SUPPORTING DEVICES

A. Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. Clevis Hangers: For supporting 2" rigid metal conduit; galvanized steel; with 1/2" diameter hole for round steel rod; approximately 54 pounds per 100 units.
2. Riser Clamps: For supporting 5" rigid metal conduit; black steel; with 2 bolts and nuts; and 4" ears; approximately 510 pounds per 100 units.
3. Reducing Couplings: Steel rod reducing coupling 1/2" x 5/8"; black steel; approximately

16 pounds per 100 units.

4. C-Clamps: Black malleable iron; 1/2" rod size' approximately 70 pounds per 100 units.
5. I-Beam Clamps: Black steel, 1-1/4" x 3/16" stock, 3/8" cross bolt; flange width 2"; approximately 52 pounds per 100 units.
6. One-Hole Conduit Straps: For supporting 3/4" rigid metal conduit; galvanized steel; approximately 7 pounds per 100 units.
7. Two-Hole Conduit Straps: For supporting 3/4" rigid metal conduit, galvanized steel; 3/4" strap width; and 2-1/8" between centers of screw holes.
8. Hexagon Nuts: For 1/2" rod size; galvanized steel; approximately 4 pounds per 100 units.
9. Round Steel Rod: Black steel; 1/2" diameter; approximately 67 pounds per 100 feet.
10. Offset Conduit Clamps: For supporting 2" rigid metal conduit; black steel; approximately 200 pounds per 100 units.

2.4 ANCHORS

A. Provide anchors of types, sizes and materials indicated; and having the following construction features:

1. Lead Expansion Anchors: 1/2", approximately 38 pounds per 100 units.
2. Toggle Bolts: Springhead; 3/16" x 4"; approximately 5 pounds per 100 units.

2.5 SLEEVES AND SEALS

A. Provide sleeves and seals, of types, sizes and materials indicated, with the following construction features:

1. Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sizes indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

2.6 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.7 FABRICATED SUPPORTING DEVICES

A. General: Shop or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 EXECUTION

3.1 GENERAL

A. Provide supporting devices that comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified. Where more than one type of supporting device meets indicated requirements, selection is Contractor's option.

B. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installations of supporting devices.

C. Coordinate with the building structural system and electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.

D. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.

E. Obtain approval from the Architect before drilling or cutting structural members.

F. Install surface-mounted cabinets with minimum of four anchors.

3.2 MISCELLANEOUS SUPPORTS

A. Support miscellaneous components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, boxes, and other devices.

3.3 FASTENING

A. Unless otherwise indicated, fasten items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, cabinets, boxes, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts, or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut into reinforced concrete beams or in concrete shall not cut reinforcing bars. If the Contractor cuts into any reinforcing bars, stop work and notify the Architect immediately. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

3.4 TESTS

A. Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:

1. Expansion anchors.
2. Toggle bolts.
3. Powder-driven threaded studs.

3.5 Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION 27 529

SECTION 27 0533

CONDUITS, BACK BOXES, AND FITTINGS FOR
COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install a complete structured cabling conduit system including conduit, hangers, back boxes, pull boxes, floor boxes, bushings, fittings, etc. for the communication systems as shown on the Drawings, specified or otherwise required.

PART 2 PRODUCTS

2.1 CONDUITS

1. Conduits shall be installed per Raceway Specification Section 270539 of this specification except as noted. The sizes of conduits shall be as shown on the drawings, minimum size is 1". All conduits shall be reamed and furnished with insulation and/or grounded bushings as required.

B. Flexible Steel Conduit
1. Flexible steel conduits are not acceptable for communication systems installations

C. Rigid and Intermediate Metal Conduit (IMC)
1. Conduit shall be steel, hot dipped zinc galvanized (min. .0008 in thick) inside and out, with circular cross section, uniform wall thickness, continuously welded seams and chamfered threaded ends. Conduit shall be furnished in ten foot standard lengths.

D. Electrical Metallic Tubing (EMT)
1. EMT shall be zinc galvanized (min. .0008 in thick) inside and out, with circular cross section, uniform wall thickness and continuously welded seams. EMT shall be furnished in ten foot standard lengths.

E. Electrical Non-Metallic Tubing (ENT)
1. ENT for use in buildings in accordance with Article 362 of the NEC. ENT shall be provided in standard coil lengths. Orange ENT will be used for communications cable.

F. Liquid-Tight Flexible Steel Conduit
1. Conduit shall be hot dipped zinc galvanized inside and out and made from one continuous length of high grade steel strip of uniform weight and thickness shaped into interlocking convolutions with smooth interior and exterior surfaces. Conduit shall be provided in standard coil lengths.
2. Conduit shall have a continuous PVC jacket enclosing it.

G. PVC Conduit
1. PVC conduit shall be rigid non-metallic Schedule 40 heavy wall.

2.2 WORK OUTLET BACK BOXES

A. Each communications outlet shall be a 4-11/16" square double gang deep (2-1/8" deep) box with raised single gang plaster ring as required and 1" conduit stubbed out above the suspended ceiling

into the bar joist area, or stubbed out below the floor into the bar joist area below as indicated on the drawings. Conduit to have a 90 degree bend turned towards the main cable routing path or cable tray and have an insulated bushing installed.

B. Conduits extended to the cable tray and/or otherwise extended beyond the turn out, shall have a grounding bushing installed and be bonded to the data/telecommunication grounding system.

C. In rooms with cable trays, conduits will be terminated with a grounding bushing within 10” of the cable tray and 2” above the side of the cable tray. The conduit will be grounded to the cable tray.

D. Communications outlet mounting height shall be ADA compliant, 18" to the top of the box above finished floor (A.F.F.) unless noted otherwise (Contractor to verify). Each communications outlet shall be provided with a matching blank cover plate unless noted otherwise. Outlet faceplates shall be as noted on the drawings.

E. Each wall phone outlet shall be a 4-11/16" square double gang deep (2-1/8" deep) box with reinforced support, stud to stud and 1" conduit stubbed out as above, with a Commscope UNF-WL4-IP-ST stainless steel plate or as required to match the phone. Mounting height of the phone shall be 44" to the top of the gang box from finished floor. Contractor to verify outlet height requirement.

F. Flush mounted phones with recessed back boxes shall have one (1) 1.00" conduit stubbed out above the suspended ceiling into the joist area or stubbed out below the floor into the bar joist area below as indicated on the drawings.
   1. Back boxes for flush mounted phones will be provided to the contractor by the Owner for the Contractor to install per the phone’s shop drawings.
   2. The center of the back box for flush mounted phones will be 42” above finished floor.

G. Each surface mounted vandal proof wall phone or emergency phone outlet shall be a 4-11/16" square double gang deep (2-1/8" deep) box with reinforced support, stud to stud and 1.00" conduit stubbed out as above, with a Commscope UNF-WL4-IP-ST stainless steel plate or as required to match the phone. Mounting height of the phone shall be 44" to the top of the gang box from finished floor. Contractor to verify outlet height requirement.

2.3 BOX ELIMINATOR MOUNTING PLATES

A. Every attempt shall be made to route the cables within the walls. With the Owner and Engineer's prior approval, at locations where pre-stubbed conduits and outlet boxes have not or cannot be installed in the wall, the Contractor shall install an approved single gang and/or double gang mounting plate/bracket (e.g. Caddy #MPLS, MPLS2, Arlington #LV1, LV2 or Owner and Engineer approved equal), and "fish" the cables within the existing wall structure, to a location above the ceiling.

B. The Contractor shall furnish and install an approved bushing or grommet in all studs and/or drywall to prevent damage to cables. Minimum grommet/bushing size shall be 1.25" I.D.

C. In those locations where data/communication cables must be fished through a concrete block wall to a "mudded-in" rework box, the Contractor shall "fish" the wall with an approved convoluted sleeving, non-metallic tubing as required to prevent damage to the cable.

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D. All wall openings shall be neatly cut and trimmed with a drywall saw. Use of a proper template is recommended. No rough or exposed edges will be permitted.

E. The faceplate shall be mounted to the box eliminator and shall be neatly installed and plumb to the floor. No exposed cables will be permitted.

2.4 PULL BOXES AND FITTINGS

A. Pull boxes shall be constructed of code gauge steel, etched, primed and shall have rust resistant ANSI 61 gray finish and be NEMA 1 construction with screw covers unless noted otherwise. For conduits 1-1/4" and larger terminating in a pull box, the minimum length of pull box shall be 8 times the diameter of the largest conduit terminating in the pull box. Splice boxes shall be sized as per EIA/TIA-569A Table 5.2-3.

B. Pull boxes shall be placed in straight sections of conduit runs and should not be used in lieu of a bend without approval of the Engineer. Pull boxes and/or splice boxes shall be installed in readily accessible locations. Where boxes are installed above suspended ceilings, they shall be located immediately above the suspended ceiling or the ceiling shall have a suitably marked and hinged panel or equivalent to facilitate direct access to the pull box.

C. Location and sizes of pull boxes and splice boxes shall meet the approval of the Owner and Engineer. Conduit type fittings (e.g. LB's, etc.) shall not be used in lieu of pull boxes or bends.

D. Exposed pull boxes in public areas shall be provided with tamperproof screws.

E. Boxes shall be provided without knockouts and shall not have any open or unused knockouts or other openings.

F. Pull boxes for indoor wet or damp locations shall be NEMA 3R Rated with stainless steel screws.

G. Pull boxes for outdoor locations shall be NEMA 4X Rated stainless steel continuous hinges, door clamps and a hasp.

H. All pull boxes 18” x 18” or larger will have hinged covers.

2.5 CONDUIT FITTINGS

A. All rigid, IMC and EMT fittings shall be galvanized malleable iron or steel. Connectors and couplings shall be threaded, setscrew or compression type, concrete-tight.

B. Conduit bodies shall be malleable iron, threaded type. Provide neoprene cover gaskets for conduit body covers exposed to the weather.

C. Expansion fittings shall be O-Z/Gedney Type "AX" for rigid metal conduit and Type "TX" for electrical metallic tubing. For intermediate metal conduit applications, a 15 inch minimum length of rigid metal conduit shall be used with a Type "AX" expansion fitting. Provide O-Z/Gedney Type "BJ" bonding jumpers at all expansion fittings.

D. Rigid and IMC conduit bushings shall be of the insulated type with phenolic thermosetting insulation molded to a hot dipped galvanized malleable iron body of the threaded type.

E. EMT fittings shall be of the insulated throat type. Fittings larger than 2-1/2 inches shall have

threaded bushings installed.

F. PVC conduit fittings shall be slip joint type.

G. All conduit sleeves will be fitted with “spillways” to maintain the bend radius of cables passing through the sleeve.

2.6 INNER DUCTS

A. Contractor to provide an approved slit corrugated inner duct of the appropriate size approved by the engineer/owner over all exposed (NON-ARMORED)sections of fiber optic cables in the MDF's, BDF's and IDF's.1” is the minimum size inner duct.

B. Contractor to provide an approved slit corrugated inner duct of the appropriate size approved by the engineer/owner over all sections of (NON-ARMORED) fiber optic cables run exposed in cable trays or otherwise exposed in ceilings and open wiring environments. 1” is the minimum size inner duct.

C. Contractor to provide spare split corrugated inner ducts of the appropriate size approved by the engineer/owner where indicated on the Engineering Drawings and as required by these specifications. 1” is the minimum size inner duct.

D. Contractor to provide four (4) inner-duct of the appropriate size approved by the engineer/owner as manufactured by Carlon in activated 4" telecommunications conduits. Each inner-duct will have a pull tape installed. 1” is the minimum size inner duct.

E. All fiber optic cable installed in conduits shall be installed in an inner duct of the appropriate size as indicated on the Engineering Drawings and as required by these specifications, unless the conduit is sized so only the fiber optic cable is installed in the conduit.

F. Contractor shall provide a pull tape in each inner duct.

G. Inner ducts shall be provided as individual continuous runs, free from interruptions and splices except where limited by the available reel length.

H. Breaks or splices in inner duct shall be exposed or located in pull boxes only.

I. Corrugated slit inner duct shall be riser or plenum rated as required, as manufactured by Carlon/Pyramid.

J. Contractor to utilize vendor manufactured couplings only for splicing the corrugated inner duct as per manufacturer's directions.

K. Contractor to provide vendor manufactured threaded aluminum couplings to join ribbed inner duct to the split corrugated inner duct.

L. Contractor to follow the manufacturer's installation instructions closely for the inner duct and cable guide.

M. Cables installed in exposed inner ducts shall be of the same riser/plenum rating as the inner duct.

2.7 FLOOR BOXES

A. Floor boxes to be provided and installed by Electrical Contractor, coordinate face plate requirements with Electrical Plans prior to ordering product.

B. Boxes to have independent wiring compartments to allow for power receptacles and communication connections within the same box

C. On-grade boxes to be cast-iron, and above grade, in-slab boxes to be steel.

D. Boxes to be fully adjustable, before and after the concrete pour.

E. UL Listed

F. Flangeless covers in die-cast aluminum with brushed aluminum finish.

G. Contractor to provide all parts, pieces, and accessories required for a working floor box system.

2.8 Refer to Data/AV/Electrical drawings for quantities, locations.

PART 3 EXECUTION

3.1 INSTALLATION

A. Conduits, back boxes, pull boxes, etc. shall be furnished and installed by the Electrical Contractor.

B. Conduits shall be sized as noted on the drawings. Where sections of conduit runs are longer than 100'-0", or have more than 180° of bends, or have a reverse (greater than 90°) bend, pull boxes shall be provided and installed. Bends in conduits larger than 2", shall be long sweep bends. Unless otherwise noted, in no instance shall the inside radius of bends be less than:
   1. Six times the internal diameter for conduits 2" and smaller.
   2. Ten times the internal diameter for conduits 2-1/2" and larger.

C. Conduits runs shall have a maximum of two 90° bends.

D. Conduits entering telephone and data rooms shall terminate as close as possible to the wall through which the conduits enter, unless otherwise noted. In-floor conduits shall terminate 4” A.F.F. or curb unless noted otherwise. All conduits shall be left clean, dry and free of debris or other obstructions, with insulated grounding bushings installed.

E. All exposed conduit shall be full weight rigid steel or IMC galvanized or sherardized inside and out.

F. Conduit in stud partitions or interior block walls, concealed above ceiling or above the bottom chord of bar joists may be electrical metallic tubing.

G. Feeder conduits in open unfinished areas larger than 2" shall be full weight rigid steel or IMC galvanized or sherardized inside and out, and routed above the bottom chord of bar joist or on "unistrut" conduit racks.

H. Conduit in unfinished areas, open ceilings in finished areas, mechanical equipment rooms, electrical equipment rooms, chases and areas subject to physical abuse shall be exposed rigid galvanized steel or intermediate grade conduit unless otherwise noted.

I. Exposed exterior conduit, conduit in tunnels or in exterior block walls shall be full weight rigid galvanized steel.

J. Conduit buried in concrete slab pours shall be full weight rigid galvanized steel or Carlon Schedule 40 PVC. All elbows, stub ups and conduit above ground shall be rigid galvanized steel. All joints and terminations for PVC shall be made according to manufacturer's recommendations using "Carlon Solvent Weld Cement" to insure all joints are watertight.

K. Conduit buried in or beneath building slabs or exterior below grade shall be full weight rigid galvanized steel or Carlon Schedule 40 PVC. The conduit will be encased in 3" concrete envelope or as called for on the Plan Drawings. All elbows and stub ups shall be rigid galvanized steel. All joints and terminations for PVC shall be made according to manufacturer's recommendations using "Carlon Solvent Weld Cement" to insure all joints are watertight.

L. Conduits and cables entering from outside the building shall be sealed water and moisture tight.

M. Seal between conduit and sleeves, conduits and core drilled holes and around conductors inside conduits. Provide cast iron pipe or Schedule 40 galvanized steel conduit sleeves in exterior walls below grade, with intermediate wall stop and anchor collar set in place before concrete pouring. Sleeve shall be a part of the sealing assembly. When the wall opening is core drilled, the wall sleeve may be omitted. A mechanically compressed rubber sealing assembly equal to Thunderline Corp. "Link-Seal" shall be placed in the annular space between conduit and sleeve or core drilling.

N. All power devices and power sources emit a given amount of radio frequency interference (RFI) and/or electro-magnetic interference (EMI). To reduce or eliminate the field effects of RFI/EMI on data traffic on a given cable channel, cable runs shall be kept at the maximum possible distance from such sources. Running cables through the center of the building can reduce the external interference effects of RFI/EMI. Inner ducts, open wiring or non-metallic raceway shall be routed a minimum of twelve (12") inches away from fluorescent fixtures and power wiring. Special attention shall be given to the routing of such pathways away from lighting ballasts and high intensity discharge devices. The minimum separation distances between data/communication distribution pathways and power wiring of 480 Volts or less shall be per Table-3, Section 270529 therein.

O. Provide continuous conduits across unexposed areas or areas of inaccessible ceilings.

P. Provide conduits between isolated areas of accessible ceilings to provide a continuous pathway for wiring from main equipment location to each device. Floor outlets in slab on grade shall have conduits run up nearest column or wall to above accessible ceiling. Poke-thru type outlets shall have conduits run to above ceiling of main corridor on the floor below.

Q. Restore all fire ratings of walls, floors and ceilings penetrated by conduits.

R. Provide a pull box in each conduit run that exceeds 100 feet in length. All pull boxes shall have straight through conduit entrance and exit. Pull boxes shall be installed in accessible locations.

S. Exposed conduit work shall be kept as inconspicuous as possible and shall be laid out in a neat workmanlike manner, parallel and perpendicular to building steel, without runs diagonal to the building walls. Paint conduits to match walls or ceilings.

T. A polyethylene pull string shall be installed in all communications conduits and a pull string will

remain in all conduits when the cables under this contract are installed.

U. All conduits shall be substantially supported by pipe straps or suitable clamps or hangers, at intervals not to exceed 8'-0", so attached to the structure of the building as to provide a substantial and rigid installation. Conduit straps for surface mounted conduit work shall be one- hole malleable with clamp backs. Joint use of hangers with heating and plumbing lines will not be permitted and conduits shall be installed above piping wherever possible.

V. Sleeves through walls and/or floors will be hilti 653 Speed Sleeves Fire Rated Pathways. The number and size of the Hilti Speed Sleeves with appropriate quantities at each wall or floor penetration will be based on the approved pathway size.

W. Conduits through fire rated floors and walls shall be rigid galvanized steel conduit with insulated and/or grounding bushings as per specifications, sized as per the schedule herein. Conduit sleeves shall be a minimum 12" long. Install fire stop as per specifications and codes upon completion of the work.

X. Where spare sleeves are required or shown on the Drawings through walls and/or floors they will be Hilti Speed Sleeves. The quantity will be per the prints and specifications.

Y. Where spare conduits are required or shown on the Drawings through walls and/or floors they will be galvanized rigid conduit threaded on both ends with galvanized pipe caps, not bushings with inserts or blanks. Spare conduits shall be located free of obstruction so that Erikson couplings can be added at a later time.

Z. Furnish and install pipe sleeves as shown on the Drawings. The sleeves shall extend 4" above the floor and a minimum of 2" below the bottom of ceiling slab. The inner edges of the sleeve at both ends shall be reamed, providing a smooth surface to prevent damage to cable insulation. Sleeves shall be equipped with metal caps to ensure fireproofing between floors and/or insulated bushings (when occupied). Sleeves shall be installed plumb and shall be vertically aligned to provide a clear vertical pull of cable without offsets. The number, size and location of sleeves shall be as shown on the Drawings or required for cable count.

AA. Surface mounted raceway shall be installed in such a manner as to minimize the amount of visible raceway. It shall be kept as inconspicuous as possible and shall be laid out in a neat workmanlike manner without runs diagonal to the building walls.

BB. All metallic surface mounted raceway components shall be field painted to match the wall or ceiling color, unless otherwise noted.

CC. The following pertains to all concrete encased ducts. As soon as the concrete is poured, and before concrete sets, blow a Greenlee type piston through each conduit and leave a 1/8" nylon pull cord and a trace wire in each conduit.

DD. Conduits shall not be installed on top of joists or beams within the convolutions of the metal deck.

EE. All conduits shall be supported against the bottom of the top cord of the joist. No conduits shall be fastened to the bottom cord of joist.

FF. One or two-hole conduit straps only are acceptable exposed below the ceiling or below 10 feet above the finished floor.

GG. Spring steel bolted type (Minerallac) conduit hangers and spring steel multifunction utility clip type

conduit hangers are not acceptable below ceilings or exposed below 10 feet above the finished floor.

HH. Conduit shall be independently supported from elements of the building and shall not rest on, nor be supported from suspended ceilings. Boxes shall be fastened to structure independently from conduit system.

II. Pull boxes not otherwise accessible in ceilings and walls shall be made accessible by the installation of hinged door access panels.

JJ. Layout the conduit system to avoid crossing building expansion joints. Where crossings are necessary, use expansion joints.

KK. Exposed conduits rising from the floor shall have a nominal 4 inch high concrete curb with chamfered edge, encasing the conduits at the floor. Conduits to terminate 4" A.F.F. or curb.

LL. Maintain minimum clearances of 6 inches clear from parallel steam, water, sprinkler, etc. piping, 4 inches from crossovers and 12 inches from generator exhaust piping.

MM. Do not install wall mounted flush boxes back-to-back in opposite sides of a wall, in stud walls, boxes shall be on opposite sides of studs.

NN. Sleeves for passage of communications conduit and wireways shall be placed in the initial stages of construction before concrete, masonry and other general construction activity. Means shall be taken to assure that the sleeve will not move during or after construction.

OO. Beams, columns and other structural members shall not be sleeved except upon written approval of the Associate Structural Engineer.

PP. Sleeves installed after initial construction, by means of core boring, etc. shall be mechanically retained in place while the wall and/or floor restoration is completed. Sleeves retained in place by means of the fire stop materials only are not acceptable.

QQ. Sleeves which are a part of fire stopping assemblies shall conform to the requirements of the assembly with particular emphasis regarding size, annular space, length, passage on non- passage of insulation and the installation of the sleeves.

RR. Conduits feeding floor boxes installed in the slab on grade shall be routed through the slab concrete, above the vapor barrier, protected from moisture.

SS. Provide all core drilling, cutting, patching, painting and restoration of all areas required to install all communications conduits, boxes, etc. Seal all core drills after raceway installation.

TT. Where conduits requiring no pipe sleeves pass through floors, walls or partitions, the annular space shall be closed with mastic materials and methods compatible with the wall, floor or partition materials to retard the passage of smoke and allow nominal movement of the conduit.

UU. Prior to the installation of any exposed conduits and boxes, the placement and conduit routing shall be reviewed and approved by the Owner's representative.

VV. All exposed conduits, raceway, boxes, etc. shall be painted. Paint color shall be coordinated by the Architect with the Owner's representative and verified by the Contractor.

WW. All conduits and sleeves shall be reamed, de-burred and provided with grounding bushings, insulated grounding bushings or non-metallic insulated bushings as applicable.

XX. Raceway systems shall be bonded to the telecommunications grounding system as per N.E.C. Article 250, EIA/TIA-607 a standard and Section 270526.

YY. Contractor shall furnish and install Osburn Associates F04002, 1-3/4: x 3" "Fiber Optic Caution" flags every 4 feet on any inner duct exposed between conduit and the equipment racks.

ZZ. The Contractor shall submit 30 days prior to commencement of installation or as otherwise directed for Owner and Engineer review and acceptance, drawings indicating cable tray, conduit or other raceway routing, size, cable fill, etc. as required to verify that the installation will meet all aspects of the Specification.

END OF SECTION 27 0533

SECTION 27 0536
CABLE TRAYS FOR COMMUNICATION SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 27 Sections apply to this section:

1. Basic Communication System Requirements.
2. Common Work Results for Communication.
3. Hangers and Supports for Communication Systems.

1.2 SUMMARY

A. This section includes metallic cable trays. Types of cable trays in this section include the following:

1. Wire Basket Type.

1.3 DEFINITIONS

1. Refer to NEMA Standard VE 1 for definitions of cable tray terminology used in this section.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:

B. Product Data for wire basket tray products.

C. Shop Drawings: Layout floor plans and elevations showing cable tray system. Designate components and accessories including clamps, dividers, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings. Show accurately scaled components and spatial relationships to adjacent equipment. Show tray types, dimensions, and finishes.

D. Factory Test Reports: Certified copies of factory test reports performed in conformance with NEMA Standard VE 1 on wire basket trays of types and size specified for this project.

1.5 QUALITY ASSURANCE

A. Manufacturer: Firms regularly engaged in manufacturer of wire basket trays whose products have been in satisfactory use in similar service for not less than 5 years.

B. UL and NEMA Compliance: Wire basket trays and components shall be listed and labeled by UL and comply with NEMA Standard VE 1, "Cable Tray Systems."

C. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

D. Single-Source Responsibility: All wire basket tray components shall be the product of a single manufacturer.

E. Coordination Drawings: Include wire basket tray systems in coordination drawings.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

1. B-Line Systems, Inc.
2. Cablofil

2.2 CABLE TRAYS - GENERAL REQUIREMENTS

A. Wire basket tray systems shall be of indicated types, sizes, and NEMA classes and shall be complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold- down devices, grommets, and blind ends as required and indicated.

B. Wire basket tray products shall have rounded edges and smooth surfaces.

C. Wire basket trays shall be manufactured from high strength steel wires. Wire to be welded, formed, and coated after fabrication.

D. Straight section to be provided in 10’ sections.

2.3 MATERIALS AND FINISHES

A. Wire Basket Trays, Fittings, and Accessories: Carbon Steel.

B. Wire Basket Trays, Fittings, and Accessories: Hot Dip Galvanized Finish. Hot dip galvanizing to be applied to welded and formed wire mesh surfaces.

C. Minimum Tray Bending Radius: 12 inches.

2.4 SIZES AND CONFIGURATIONS

A. Wire Basket Tray Mesh Opening: 4” x 2”

B. Wire Basket Side Rail Depth: As required by cable fill ratio.

C. Wire Basket Tray Width: As noted on drawings.

2.5 SUPPORTS AND CONNECTORS

A. Wire basket tray supports and connectors, including bonding jumpers shall be as recommended by wire basket tray manufacturer.

B. Supports shall be spaced a maximum of 5' on center and at all change of directions.

C. Wire basket tray support system shall be installed at manufacturer's suggested support span of 5' at a span load of L/300.

2.6 FASTENERS FOR SUPPORTS

A. Fasteners to connect wire basket tray supports to the building structure shall be as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.
3. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.

2.7 FIRE STOPPING

A. General: Materials shall be UL listed and labeled and FM approved for fire ratings consistent with penetrated barriers.

B. Sleeves: HILTI 653 speed sleeves. Sizes as indicated or minimum NEC size for cable or cable group to be installed.

C. Sealing Fittings: Suitable for sealing cables in sleeves or core drilled holes.

D. Sealing Mortar: Suitable for sealing cable penetration slots/openings in fire barriers.

E. Sealant: One-part compound for sealing cables, sleeves, and openings in fire barriers.

F. Two-Part Sealant: Formed-in-place sealant as specified in Division 26 Section 26 0500 Common Work Results for Electrical.

2.8 WARNING SIGNS

A. Lettering: 1-1/2-inch high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

2.9 Materials and Fastening: Conform to Section "Electrical Identification."

PART 3 EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which the wire basket trays are to be installed, coordinate locations with all other Contractors and light fixtures. The exact location will be as directed by Owner/Architect. Provide all necessary steel supports, hanger rods, and miscellaneous hardware. Provide all necessary horizontal and vertical offsets to complete the installation around obstacles, building structure, and other systems.

3.2 INSTALLATION OF CABLE TRAY SYSTEMS

A. Wire basket tray shall be installed with a minimum 18" clearance from light fixtures, electrically operated equipment, and all wiring operating at 120 or more volts.

B. Install cable trays in accordance with equipment manufacturer's written instructions.

C. Remove burrs and sharp edges of wire basket trays.

D. Support cable trays independently from the building structural components.

E. Cable Basket Trays shall be supported using a Trapeze solution. The use of center spline supports is not acceptable.

F. Conform to manufacturer's recommendations for selection and installation of supports.

G. Support Locations: Locate supports in accordance with the recommendations of the wire basket tray manufacturer.

H. Installation of supports shall be in accordance with wire basket tray manufacturer's written instructions and the recommendations of Paragraph 6.5 of NEMA Standard VE 1.

I. Support at Connections to Equipment: Where wire basket trays connect to equipment, provide flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.

J. Thermal Contraction and Expansion: Install expansion connectors in wire basket tray runs as recommended by the manufacturer.

K. Direction Changes: All bends, intersections, elevation changes, reducers, etc., are to be field-fabricated utilizing straight sections, hardware, and instructions provided by the manufacturer.

L. Locate wire basket tray at heights indicated on the “T” Series Drawings

M. Fire stopping: Where wire basket trays penetrate fire and smoke barriers including walls, partitions, floors, and ceilings, install fire- stopping at penetrations after cables are installed.

N. Sleeves For Future Cables: Install capped sleeves for future cables through fire stopped wire basket tray penetrations of fire/smoke barriers.

O. Working Space: Install wire basket trays with sufficient space to permit access for installing cables.

P. Barriers: Where trays carry conductors of different systems, such as television, communications, and data processing, install barriers to separate the systems

3.3 GROUNDING

A. Electrically ground wire basket trays and ensure continuous electrical conductivity of wire basket tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.

3.4 WARNING SIGNS

A. After installation of wire basket trays is completed, install warning signs, on or in proximity to wire basket trays, where easily seen by occupants of space.

3.5 FIELD TESTING

A. Grounding: Test wire basket trays to ensure electrical continuity of bonding and grounding connections.

B. Anchorage: Test pull-out resistance of one of each type, size, and anchorage material for toggle bolts and powder-driven threaded studs.

C. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the Architect's approval before transmitting loads to the structure. Test to 90 percent of rated proof-load for fastener. If fastening fails test, replace fastener and retest until satisfactory results are achieved.

3.6 CLEANING AND FINISH REPAIR

A. Upon completion of installation of wire basket trays, inspect trays, fittings, and accessories. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

B. Galvanized Finish: Repair damage with a zinc-rich paint recommended by the tray manufacturer.

3.7 END OF SECTION 27 0536

SECTION 27 0539
SURFACE RACEWAYS AND BOXES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install a complete structured cabling surface mounted raceway system, including base, cover, divider, inside corners, outside corners, flat bends, tee's, crossovers, crosses, device plates, faceplates, feeder boxes, end fittings, etc. for the communications system as shown on the Drawings, specified or as otherwise required.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Raceways shall be as indicated on the Engineering Drawings and sized as required to provide a minimum 55% spare growth capacity.
   1. Raceways shall be of a single, double or triple channel design as indicated.
   2. Raceway shall be Office White (non-metallic) or Ivory (metallic) in color or paintable, as approved by the Architect.
   3. The surface mounted raceway will include all fittings for mounting and mating the raceway system. Fittings shall overlap raceway to hide all cuts. The fittings available shall include at the minimum the following:
      a. Mounting Clips
      b. Mounting Straps
      c. Flat, Internal Elbows
      d. External Elbows
      e. Cover Clips
      f. Tees
      g. Couplings
      h. Entrance Fittings
      i. Conduit Connectors
      j. Conduit Bushings
   4. Raceway shall utilize standard electrical and data faceplates.
   5. Raceway shall provide minimum TIA/EIA bend radius capability.
   6. Raceway located in student rooms or other areas subject to abuse shall be of a heavy duty, tamper resistant design and construction to resist damage and unauthorized access.
   7. Minimum outlet box depth shall be 2-1/8". Provide box extender as required. Provide additional depth as available.
   8. Surface mounted raceway shall be U.L. Listed and classified with U.L. labels applied.

B. Owner acceptable non-metallic raceway systems for communications are:
   1. Panduit Series TG-70, T-70, Twin 70, and T-45, surface raceway systems for communications distribution as specified on the “T” Series Drawings
      a. Ancillary branch raceway to individual outlets, as required shall be "LDP10" raceway or larger

C. Thomas & Betts/Carlon Series 90 and 900 single and triple channel cove molding raceway systems

for ceiling/wall interface communications distribution in locations identified on the prints.

a. Ancillary branch raceway to individual outlets, as required shall be Series 30 raceway or larger.

D. Panduit Series "WCM" single and double (with divider) channel cove raceway systems, similar to Item 2 above.

a. Ancillary branch raceway to individual outlets, as required shall be "LDP10" raceway or larger.

E. Owner acceptable metallic raceway system for communications is Wiremold AnySize Multi Compartment Surface Metal Raceway or the Mono-Systems Series SMS9300 3-channel raceway.

1. Raceway to consist of three (3) 3 inch x 3 inch channels. Two channels (low voltage) covered by one cover and the 3rd channel (power) covered by a second channel.
2. Provide all fittings for a complete installation and to maintain proper bend radius for communication cable.
3. Metallic raceway shall be provided with tamper resistant security screws for all covers.
4. Metallic raceways shall be provided for belt-line communications and power distribution in student residence rooms, lounges and computer labs and classrooms subject to abnormal abuse, as specified on the Engineering Drawings.

PART 3 EXECUTION

3.1 INSTALLATION

A. Where indicated on the Drawings and in the Contract Documents, surface mounted raceway for communications shall be provided by the Contractor.

B. Surface mounted raceway systems shall be as specified or otherwise indicated.

C. Surface mounted raceway systems shall be U.L. Listed and installed per the manufacturer's directions such as to maintain the U.L. Listing.

D. Metallic raceway shall be U.L. Listed as a grounded raceway system. Provide bonding jumpers as required.

E. Where indicated on the Engineering Drawings, surface mounted raceway shall be divided, providing separate isolated compartments as indicated for power, data/telecommunications and CATV.

F. Generally, the bottom section is to be utilized for power distribution, the top section utilized for data/telecommunications, and if specified, the middle section for security, fiber optics or CATV coax, etc. as indicated.

G. Duplex receptacle faceplates or device brackets shall be provided utilizing a 106 duplex mounting frame for data/telecommunications outlet as per the Connectivity Schedule on the Engineering Drawings.

H. Unless noted otherwise, surface mounted raceway shall be fed utilizing a minimum 3/4” conduit and recessed handy box for power and a 1-1/4”C and recessed 4-11/16” square x 2-1/8” deep double gang box with raised single gang plaster ring for CATV and data/telecommunications. Provide one (1) 4-11/16" sq. box for every five (5) cables to be installed.

I. Surface mounted raceways shall be firmly anchored to the wall studs or concrete/block structure.

J. Appropriate screws shall be utilized in studs. Appropriate screws and metal anchors or Engineer approved metallic anchoring system shall be utilized in concrete/block structure. Plastic anchors of any type are not acceptable.

K. Non-metallic raceways shall be provided with double-sided self-adhesive tape backing to aid in the positioning of the raceway prior to screw fastening and anchoring. All raceway shall be screw fastened for permanent attachment.

L. Contractor to furnish and install EIA/TIA-569A compliant fittings and accessories as required to provide and maintain minimum wiring space and cable bend radii requirements. Contractor to coordinate raceway size with cable fill requirements.

M. All raceway materials shall be neatly installed, running perpendicular or parallel to the floor as required. All raceway to be cut and neatly trimmed with an appropriate miter saw. No rough or exposed edges will be permitted. No exposed cables will be permitted.

N. Contractor to install the surface mounted raceway in accordance with the manufacturer's instructions and recommendations, utilizing factory furnished accessories and fittings as required. Each section of surface mounted raceway shall be secured to the wall with panhead screws or mushroom headed nail anchors on 16" nominal maximum spacing, with a minimum of two (2) anchors per section. Anchors shall be located 6" or less from the end of each raceway section as required to retain raceway tight to the surface.

O. Non-metallic raceway shall not be utilized for combined data/telecommunication and power distribution without written approval of the Engineer and Owner. Metallic raceway with a metal divider only shall be used for combined data/telecommunication and power distribution.

END OF SECTION 27 0539

SECTION 27 0553
IDENTIFICATION FOR COMMUNICATION SYSTEMS

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. Requirements of the following Division 27 Sections apply to this section:

1. Division 27 Section 27 0100 “Basic Communication System Requirements”.
2. Division 27 Section 27 0500 “Common Work Results for Communications”.

1.2 SUMMARY

A. This Section includes identification of communication cables, equipment, and installations. It includes requirements for identification components including but not limited to the following:
1. Identification labeling for cables.
2. Operational instruction signs.
3. Equipment labels and signs.
4. Cable Labeling requirements

B. Refer to Division-01 General Requirements Section, "Identification Systems" for equipment and system nameplates, and performance data; not work of this section.

C. Refer to other Division 27 sections for additional specific identification requirements associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

B. Product Data: Manufacturer's data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.4 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacture of electrical or communication identification products of types required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing identification work similar to that required for this project.

C. NEC Compliance: Comply with NEC as applicable to installation of identifying labels and markers for wiring and equipment.

D. UL Compliance: Comply with applicable requirements of UL Standard 969, "Marking and Labeling Systems", pertaining to identification systems.

E. ANSI Compliance: Comply with applicable requirements of ANSI Standard A13.1 "Scheme for the Identification of Piping Systems", with regard to type and size of lettering for cable labels.

F. NEMA Compliance: Comply with applicable requirements of NEMA Standard No's. WC-1 and WC-2 pertaining to identification of control conductors.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following (for each type marker):

1. Ideal Industries, Inc.
2. Seton Name Plate Company

PART 3 EXECUTION

3.1 GENERAL

A. The labeling scheme shall be compliant with ANSI/TIA/EIA 606 –A Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   1. The Contractor shall label, at a minimum, the following infrastructure components:
      a. Each end of each cable shall be labeled with a machine-generated wrap-around label. Inclusive of all Category 6, copper riser, Coax, fiber riser and any other Contractor-installed cable. Label is to be within 12” of the end of the cable.
      b. Each faceplate.
      c. Each Patch Panel port.
      d. Each copper-riser cable pair.
      e. Each Rack installed by the Contractor must be labeled with a plastic-engraved plastic label.
      f. Each Cabinet installed by the Contractor must be labeled with a plastic-engraved label mounted to the front and rear of the cabinet. The label shall be affixed such that the label is visible in a door-open, door-closed, or a door-off configuration.
B. All labeling shall be completed a minimum of 2-weeks prior to system cutover.
C. A Labeling plan shall be provided to the contractor prior to start of construction, all cables shall be labeled exactly as identified on the labeling plan.
D. Level 1 shall have an independent labeling scheme from level 2
E. WAPS and Cameras shall be labeled as standard data outlets on the patch field.
F. The cabling contractor shall reimburse the Owner for additional cost incurred by other vendors due to a direct result of incorrectly labeled outlets. (Labels must be correct)

3.2 The Contractor shall be responsible for a complete site walk and verification of the labels prior to cutover.

END OF SECTION 27 0553

SECTION 27 0637

COMMUNICATIONS FIRESTOPPING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Select, furnish and install U.L. approved fire stopping materials and systems as indicated on the Drawings, Specified or as otherwise required, to the approval of the Local Authority Having Jurisdiction.

1.2 SUBMITTALS

A. Contractor Submittals
   1. The Contractor shall submit to the Owner and Engineer a minimum of ten (10) days prior to installation for review and acceptance cut-sheets for fire-stopping materials and assemblies, which have been reviewed and approved by the Local Authority Having Jurisdiction (AHJ).
   2. The Contractor shall submit to the Owner and Engineer a minimum of ten (10) days prior to installation for review and acceptance the Fire Stop applicators certifications.
   3. All fire stopping adhesives to contain VOC levels of 0g/L or 0%. If materials used exceed this limit, submit cut sheets to the Owner confirming VOC levels are within project limits to adhere to LEED credit EQ 4.1.

PART 2 PRODUCTS

2.1 MATERIALS AND SYSTEMS

A. The Contractor shall provide through penetration fire stops as per ASTM E-814 and Ul-1479.
B. Fire stop systems shall have been tested by UL and meet the rating criteria, as published in the UL Fire Resistance Directory. The Contractor is referenced to the latest BICSI Telecommunications Distribution Methods Manual (TDMM) and EAI/TAI-569A Annex “A” for general guidelines and overview of fire stop technology and methods. Contractor shall consult individual manufacturer’s instructions for specific application details.

C. Openings around cable trays, cable channels, conduits or in sleeves penetrating fire-rated floor slabs, walls, partitions, ceilings or smoke partitions, shall be sealed at both sides of the partition. Pack openings with calcium silicate blocks, 3M Brand Fire Barrier Caulk “CP25” and Putty “303”, 3M Brand Series 7902/7904 systems for floor and walls, Nelson Flame Seal System, or an Owner and Engineer accepted material having the same fire-rating as the floor or wall penetrated. Fiberglass is not acceptable.

D. Where indicated on the Drawings and/or other locations where applicable, the Contractor shall utilize the HILTI 653 SPEED SLEEVE” fire rated pathway assembly(ies) to facilitate current cable pathway and future moves, adds and changes (M.A.C.’s).

E. In rooms that have an FM200 fire suppression system the walls may be penetrated by conduits only

and the conduits must be fire stopped per specifications.

F. All fire stopping systems shall be of a single manufacturer, as manufactured by 3M, Nelson, Specified Technologies, Hilti or Owner and Engineer approved equal. Contractor shall submit cut sheet to the "Authority Having Jurisdiction" (AHJ) for approval prior to submittal to the Owner and Consultant for review and acceptance.

G. The Contractor shall refer to Sections 07840 (078400), 07860 (078600) and 07870 (078700) of the Architectural Specifications for requirements for Fire stopping, Smoke Seals and Smoke Containment Barriers.
   1. The Contractor shall be responsible for meeting and complying with all applicable criteria and standards of the above sections and others as applicable.
   2. When conflict in this specification occurs with other sections of this document, the contractor is to follow the more stringent specification.

PART 3 EXECUTION

3.1 RESPONSIBILITY FOR WORK OF THIS SECTION

A. Contractor shall refer to the Life Safety Plan for the extent and location of fire barriers and ratings.

B. The Contractor shall verify with the Architect or the Local Building Authority, the fire rating requirements of any wall or floor to be breached by a conduit, cable, raceway or other penetration as per ASTM E-119 (NFPA-251 and UL-263) standards. The Contractor shall notify the Owner, Consultant, and Architect in writing of all existing non-compliant conditions for resolution.

C. The presence of existing non-compliant conditions will not exempt the Contractor from meeting the installation fire rating requirements for new construction.

D. If Contract Documents indicate, or Contractor directs, that fire stopping work is to be provided by more than one Subcontractor, each Subcontractor shall provide fire stopping as specified in the Section.

E. All penetrations into MDF's, IDF's must be fire stopped even if not required by code.

3.2 REGULATORY REQUIREMENTS

A. Fire rated assembly: Comply with construction of fire rated assemblies as acceptable to Texas Building Code enforcing agency. Materials, installation procedures and other requirements of specific assembly supersede any conflicting requirements specified herein.

3.3 QUALITY ASSURANCE

A. Fire stopping materials shall conform to both Flame (F) and Temperature (T) ratings as tested by nationally accepted test agencies per ASTM E-814, UL 1479 or UL 2079 fire tests.
B. The F rating shall be a minimum of one (1) hour, but not less than the fire resistance rating of the assembly being penetrated.
C. Conduct the fire test with a minimum positive pressure differential of 0.01 inches of water column.

D. Comparable tests by other approved testing agencies shall also be acceptable.

E. Installer shall have a copy of above-referenced fire tests available at field office.

F. Materials shall meet and be acceptable for use by the Ohio Building Code.

G. Materials shall meet the requirements of NFPA 101 – Life Safety Code and NFPA 70 – National Electrical Code.

H. Applicator qualifications: Minimum two years of experience, and trained by manufacturer or manufacturer's approved representative, in installation of UL or other approved testing agency classified fire stopping assemblies. Installer to be certified, licensed, or otherwise qualified by the fire stopping manufacturer as having the necessary experience, staff, and training to install manufacturer's products per specified requirements. A manufacturer's willingness to sell its fire stopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer qualification on the buyer.
   1. It is highly recommended by the Owner and Consultant, for liability purposes, that the Contractor avail himself of the services of a "Specialty Contractor" who is trained, experienced and certified as qualified to properly select, install and warranty his work.
   2. The Contractor shall submit the applicators certifications, shop drawings and cut sheets for materials and system to the Owner and Engineer prior to installation. Contractor to allow a minimum of ten (10) working days for review prior to installation.

I. Equipment used shall be in accordance with fire stop manufacturer's written installation instructions.

J. Sample Mock-Up: Prepare job mock-up of the material proposed for use in the location as directed by the Architect. Approved mock-ups shall be left in place as part of the finished project and shall be used as the standard for remaining work.

K. Pre-Installation conference: Prior to commencement of work of this section, coordinate with Construction Manager to schedule a meeting on site with Construction Manager, Fire stopping Contractor, a representative of fire stopping product manufacturer, Owner, Consultant, and Architect to review specifications, scope of work, and other requirements, to ensure complete compliance with specifications and understanding of job conditions.

3.4 SEQUENCING AND SCHEDULING

A. Coordinate the work of this Section as required with work performed by other trades on the project.

3.5 INSPECTION

A. Prior to installation, inspect and verify that surfaces and substrates have no defects or errors that would interfere with installation of the fire stopping materials.
   1. Notify the Owner, Consultant, and Architect of conditions which would prevent proper installation.
   2. Do not proceed until unsatisfactory conditions have been corrected or adjusted.
   3. Start of installation constitutes acceptance of surfaces and conditions of substrates.

3.6 COORDINATION

A. Coordinate:
   1. Installations with manufacturers to ensure compliance with their tested assemblies, or approved extrapolations thereof.
   2. With mechanical and electrical trades to ensure full knowledge of types and uses of pipes, ducts, conduits and similar, and with all other trades, for compliance with tested assemblies, or approved extrapolations thereof.
   3. With mechanical and electrical trades to ensure that annular spaces are kept to the minimum size necessary for passage of work of their trades and installation of fire stopping specified herein.
   4. With other trades to ensure installation of fire stopping after completion of penetrating item but prior to covering or concealing openings.

3.7 PREPARATION

A. Clean surfaces and substrates of dirt, oil, loose materials and other foreign materials which may affect the proper bond or installation of the fire stops; follow manufacturer's written instructions.

B. Unless approved by manufacturer, do not apply fire stopping material to surfaces previously painted or treated with a sealer, curing compound, water repellent or other incompatible material; remove coatings as required in compliance with manufacturer's instructions.

C. Mask where necessary to protect adjoining surfaces.

D. Provide required ventilation.

3.8 INSTALLATION OF MATERIALS IN FIRE-RATED WALLS

A. Install in strict accordance with manufacturer's printed instructions and UL or other approved testing agency regulations.

B. Do not install systems which are not in strict conformance with UL or other approved testing agency regulations unless system needed cannot meet UL or other approved testing agency regulations, and unless approve in writing by manufacturer as being equivalent to UL or other approved testing agency test.

C. Install to provide Flame (F) and Temperature (T) rating of minimum one (1) hour, but not less than the fire resistance rating of the assembly in which the fire stopping materials are being installed. At curtain wall system at building perimeter and in spaces wider than 2 inches fill with mineral fiber with foil-faced side up and seal both edges with smokestop sealant. Anchor mineral fiber with manufacturer's standard impaling clips.

D. Install anchoring devices, back-up materials, clips, sleeves, supports and other materials as used and approved in the ASTM E-814 and UL 1479 or other approved testing agency fire tests, and as approved by manufacturer.

E. Install fire stops with sufficient pressure to fill and seal holes, voids and openings to ensure an effective smoke seal. When installing mineral fiber insulation at perimeters of fire rated partitions, also install fire stopping sealant to ensure total prevention of smoke passage.

F. Tool or trowel exposed surfaces. Remove excess fire stop material promptly as work progresses and

upon completion.

G. Apply primer over sealant on surfaces to be finish painted under Section 09900.

3.9 INSTALLATION OF SEALANT IN ACOUSTICALLY RATED WALLS

A. Install in strict accordance with manufacturer's printed instructions.

B. Tool or trowel exposed surfaces. Remove excess sealant promptly as work progresses and upon completion. Ensure full contact with surfaces being sealed.

C. Apply primer over sealant on surfaces to be finish painted under Section 09900.

3.10 FIELD QUALITY CONTROL

A. Post-installation inspection: Immediately upon completion of work of this section, coordinate with Owner, Consultant, and Architect and fire stopping installing company to schedule a meeting at site with Owner, Consultant, and Architect, fire stopping installing company and a representative of the fire stopping manufacturer to review entire installation to ensure complete compliance with specifications and requirements for rated installations.

3.11 CLEANING AND ADJUSTING

A. Examine work installed herein to ensure proper installation and full compliance with this specification prior to concealing or enclosing work.

B. Work in fire-rated assemblies shall be accessible until inspection and approval by authorities from the code-enforcing authorities upon their request.

C. Correct unacceptable work and provide additional inspection to verify compliance with this specification at no additional cost to Owner.

D. Where finished work will be visible, clean adjacent surfaces in accordance with manufacturer's printed instructions.

END OF SECTION 27 0637

SECTION 27 0800

COMMISSIONING OF COMMUNICATIONS

PART 1 GENERAL

1.1 SCOPE OF WORK

A. Section Includes: Testing of Telecommunications Backbone and Horizontal Cabling subsystems.

1.2 Related Sections

A. Consult all other Sections and Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to completely test a complete and operable system.
B. Section 27 0100: Basic Telecommunications Requirements
C. Section 27 1300: Communications Backbone Cabling
D. Section 27 1500: Horizontal Cabling Systems

1.3 Products Furnished and Installed Under Other Sections:

A. Telecommunications Cabling

1.4 REFERENCES

A. Comply with Section 27 0100 References requirements.

B. Additional references to those listed in Section 27 01 00.

1. TIA/EIA-526-14 ("OFSTP-14") Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
2. TIA/EIA-526-7 ("OFSTP-7") Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant
3. TIA/EIA-455-171 Attenuation By Substitution Measurement – For Short-Length Multimode Graded-Index And Single-Mode Optical Fiber Cable Assemblies (a.k.a., FOTP-171)

1.5 DEFINITIONS

A. Refer to Definitions of Sections 27 0100, 27 13 00 and 27 15 00.

B. In addition, the following list of terms as used in this specification shall be defined as follows:

1. "Adapter" (associated with fiber connectivity): Shall mean a connecting device joining 2 fiber connectors, either like or unlike.
2. "Channel": Shall mean a testing configuration which includes the Permanent Link and the line cord (at the workstation), the equipment cord, and, if a full cross connection is implemented, a patch cord and the cross connect termination/connecting apparatus.
3. "Connect": Shall mean install all required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.

4. “Cord”: Shall mean a length of cordage having connectors at each end. The term “Cord” shall be synonymous with the term “Jumper”. The cord may be:
   a. Unshielded twisted pair
   b. Fiber (multimode or single mode), jacketed and buffered

5. “Launch Cord”: Shall mean the cord certified for use in fiber optic characterization testing, as described in this section.
6. “OTDR”: Shall mean Optical Time Domain Reflectometer.
7. “Passive Link Segment”: Shall mean the cable, connectors, couplings, and splices between two fiber optic termination units.
8. “Permanent Link”: Shall mean the ‘permanent’ portion of the Horizontal cabling to each outlet with the test cords de-embedded from the measurements; this includes cable, consolidation point (if used), termination/connecting apparatus in the IDF and the connector at the outlet.
9. “System Cord”: Shall mean the cord used in the operating electrical or optical circuit.
10. “Test Cord”: Shall mean the cord certified for use in testing, as described in this section.

1.6 SYSTEM DESCRIPTION

A. Work Provided Under Other Sections

   1. Refer to Section 27 13 00 for a more complete System Description.
   2. Backbone Cabling
      a. The Backbone Cabling includes twisted pair and fiber cabling.
   3. Horizontal Cabling
      a. The Horizontal Cabling, in general, consists of multiple 4-pair Category 6 UTP cables to each outlet. Refer to the Drawings for specific requirements.

1.7 Base Bid Work

A. Testing of a completed Telecommunications Cabling System, including:
   1. Procedures Submittals.
   2. Equipment Submittals.

1.8 COPPER TESTING REQUIREMENTS

A. Each cable shall be tested with a Fluke DSP DTX 1800 series tester for Level IV accuracy.
B. Prior to testing, the Contractor must submit documentation to the Owner stating that the tester(s) to be used on the project have been Factory re-calibrated within 30-days of use. Throughout the course of the project, the Contractor shall field re-calibrate the tester(s) on 30-day intervals.
C. The Contractor must verify the test equipment is equipped with the most recent Standard and Software versions.
D. The Contractor must provide a sample test report prior to commencing the testing process. The Owner must approve the sample test report prior to testing.
E. The Owner reserves the right to request random testing of any cable(s) during the course of the project to insure adherence to the specifications.
F. The Contractor shall submit all test reports as a portion of the documentation package. The reports

shall be submitted in .PDF and .FLW Fluke Linkware formats.

G. Each copper Horizontal cable shall be tested utilizing the following specifications:
H. In accordance with the field test specifications defined in ANSI/TIA/EIA-568-B.2-1 "Addendum 1 – Transmission Performance Specifications for 4-pair cat 6 Cabling". This document will be referred to as the "Category 6 Standard."
I. The installed twisted-pair horizontal links shall be tested from the IDF in the telecommunications room to the telecommunication wall outlet in the work area for compliance with the "Permanent Link" performance specification as defined in the Category 6 Standard.
J. One hundred percent of the installed cabling links must pass the requirements of the Category 6 Standard. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation
K. Each cable test shall reflect the "worst-case" margin versus the Cat. 6 NEXT limit.
L. The Contractor shall confirm that each cable test meets or exceeds the minimum Headroom specifications as provided by the System Manufacturer.
M. The Contractor must submit any "marginal" or "*PASS" test reports (as reported by the Fluke tester) to the Owner. At the Owner's discretion, the Contractor must identify, remedy and re-test the marginal reports.

1.9 FIBER OPTIC TESTING REQUIREMENTS

A. Unless otherwise specified by the Owner or Consultant, each cabling link shall be in compliance with the following test limits and criteria for multimode and single mode links:
B. The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA-568-B.1. **Note that the connector loss allowed (below) differs from the TIA standard** Custom Test set up within the DTX-1800 tester is required to properly complete the testing.
   1. Link Attenuation (dB) = Cable Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)
   2. Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)
   3. Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)
   4. Maximum allowable connector_loss = 0.5 dB for Multimode, 0.25 dB for Single mode
   5. Splice_Attn (dB) = number_of_splices * splice_loss (dB)
   6. Maximum allowable splice_loss = 0.3 dB
   7. The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

a. Prior to cable installation, the Contractor shall connectorize and test each fiber for continuity. If the test results indicate a broken, damaged or marginal fiber (overall loss should be similar, as determined by the Consultant, to the manufacturers loss results that accompany the spool, if not, it is considered marginal), the entire spool shall be returned to the distributor.

b. Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper or the equivalent method. The Fluke Networks DTX-MFM2 fiber modules shall be used to perform this testing. If VCSEL electronics are being utilized, the Owner or Consultant may specify the use of the Fluke Networks DTX-GFM2 modules, at their discretion.
c. Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method. The Fluke Networks DTX-SFM2 fiber modules shall be used to perform this testing.
d. Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
e. Use the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1 or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.
f. The Fluke Networks online Knowledge Base (www.flukenetworks.com) and Technical Assistance Center (800-283-5853) are recommended resources for specific questions on the proper setup and operation of the DTX-1800 in accordance with the specifications outlined above.
g. Contractor Training and Commissioning Support
h. The Contractor shall provide 2 weeks of on-site support for the cut-over phase (including weekends). Additional cutover time may be added to the contract at the hourly unit cost included in the Bid Response.
i. At a minimum, the Contractor must provide the Project Foreman beginning on the day when the move commences. The Project Foreman must remain on-site until dismissed by the Owner. The Contractor's Project Manager must be on-call for the duration of the move to assist the Project Foreman in the event assistance is required.
j. The Contractor's on-site personnel must be equipped with toners, testers, and other miscellaneous equipment (spare patch cords, spare cable, crimp tools, RJ45 plugs, etc.).

PART 2 EXECUTION

2.1 SCHEDULING

A. Schedule both the Consultant and a representative of the test equipment manufacturer for a demonstration of testing methods. Execute a demonstration of testing methods with aforementioned parties prior to 'production' testing activities. Test reports and acceptance testing will not be accepted without proof of methods demonstration.

2.2 FIELD QUALITY CONTROL

A. Complete testing as delineated below prior to system acceptance.

B. Permanently record all test results and presented in a format acceptable to the Owner or Consultant before system acceptance.

C. Remove and replace with new, at no cost to the Owner, any cables or conductors (copper or glass) failing to meet the indicated standards. The Owner will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner has approved any deviation from this requirement.

D. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day's testing and after each battery charge. Fully charge the test sets prior to each day's testing to ensure proper operation.

END OF SECTION 27 0800

SECTION 27 1100

COMMUNICATION EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Communications Equipment Room Configuration
   2. Placement / Access
   3. Layout
   4. Security
   5. Communications Mounting Elements
   6. Backboards
   7. Equipment Racks and Cabinets
   8. Grounding

1.3 RELATED REQUIREMENTS

A. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
B. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
C. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
D. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.
E. Section 061000 "Rough Carpentry

1.4 DEFINITIONS.

A. BICSI: Building Industry Consulting Service International.
B. LAN: Local area network.
C. RCDD: Registered Communications Distribution Designer.
D. Telecommunications Room (IDF): An enclosed architectural space for housing telecommunications equipment, cable terminations, and cross-connect cabling. For purposes of this document the IDF will also be referred to as “Communications Equipment Room.”
E. Entrance Telecommunications Room (ETR): An enclosed architectural space for housing telecommunications equipment, cable terminations, and cross-connect cabling. This room is where outside communication services enter the building.

1.5 SUBMITTALS

A. Product Data: For each type of product.

B. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
C. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
D. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
E. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

F. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.

G. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets. Retain "Seismic Qualification Certificates" Paragraph below if required by seismic criteria applicable to Project. Coordinate with Sections specifying telecommunications equipment supports and seismic controls. See ASCE/SEI 7 for certification requirements for equipment and components.

1.6 QUALITY ASSURANCE

A. BICSI is an industry trade association. See Editing Instruction No. 2 in the Evaluations for summaries of qualifications for registration.
B. Installer Qualifications: Cabling Installer must have personnel certified on staff.
C. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of a RCDD and shall be coordinated thru LSU"s Information Technology Services department.

D. Installation Supervision: Installation shall be under the direct supervision a qualified trained technician and who shall be present at all times when Work for this Section is performed at Project site.

E. Field Inspector: Shall be currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 PRODUCTS

2.1 See Editing Instruction No. 1 in the Evaluations for cautions about named manufacturers and products. For an explanation of options and Contractor's product selection procedures, see Section 016000 "Product Requirements."

2.2 BACKBOARDS

A. Backboards: Provided and installed by General Contractor as indicated on the "T" series Drawings. Plywood, fire-retardant treated or painted with two coats of nonconductive fire retardant paint, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry." All backboards will be finished in a light color to increase illumination (even fire-resistant plywood shall be painted, but this paint does not need to be fire retardant). Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant

plywood, do not paint over manufacturer's label.

2.3 EQUIPMENT FRAMES

A. General Frame Requirements:
   1. Distribution Frames: Freestanding and wall-mounting, modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
   2. Module Dimension: Width compatible with 19-inch panel mounting.
   3. Panel mounting holes are to be #12-24 tapped on EIA universal spacing on both front and rear of rack.
   4. Floor-Mounted Racks: Modular-type aluminum construction black in color.
   5. Vertical and horizontal cable management channels, top and bottom cable troughs.
   6. Racks are to be black in color, seven (7') foot high, nineteen (19") inch rack space.
   7. The rack must be self-supporting with base suitable to floor mount.
   8. Must be equipped with a grounding lug.
   9. Must have 6” vertical channels for mounting heavy loads.
   10. Cable Management for Equipment Frames:
   11. Metal or plastic, with integral wire retaining fingers.
   12. Vertical cable management panels shall be double sided and have front and rear channels, with covers.
   13. Provide horizontal cable managers as specified on the rack elevations within the “T” series drawings
B. GROUNDING
   1. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
   2. Comply with J-STD-607-A.
   3. Telecommunications Main Grounding Bus Bar (TMGB):
      a. Connectors: Mechanical type, cast silicon bronze, solderless compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
      b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
      c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
   4. Telecommunications Grounding Bus Bar (TGB):
      a. Connectors: Mechanical type, cast silicon bronze, solder less compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
   5. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
      a. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
      b. Bonding Conductor (BC):
      c. 6 AWG stranded conductor with a green jacket.

2.4 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers. Labels shall be made using a mechanical label

maker. Permanent marker, ink pen, and/or pencil labels shall not be accepted. All labels shall be permanent; no hanging/paper tags.

2.5 LADDER TRAY:

A. Sizes per the "T" Series Drawing Requirements

1. Tray must be installed with the proper mounting hardware to securely fasten the tray to the walls and the top of the Floor-Mounted Racks.

2. Must be equipped with the proper grounding lugs to assure proper grounding and bonding of the tray.
3. The ladder tray should be selected to support the amount of cable at a 50 percent fill ratio per ANSI/TIA/EIA 569-A.

4. Tray must be constructed of tubular channel and shall be black in color

PART 3 EXECUTION

3.1 General Communications Equipment Room Requirements:

A. LAYOUT: Room configuration will be laid out in accordance Enlarged plans in the "T" series drawings. If any changes are needed to the basic flow and layout of the rooms, then the contractor's RCDD shall coordinate those changes the consultant.
B. USAGE: ALL Telecommunications rooms shall be free of electrical distribution panels, inverters, air handlers, sinks, wash basins, plumbing, janitorial storage areas and other equipment. Telecommunications rooms shall contain communications equipment only. No Telecommunications Room shall be used as a pass thru for any other building services (ie. water, gas, exhaust vents, etc.)
C. LIGHTING: All telecommunications rooms must be 500 lux (50 foot candles) at a distance of three feet (3') above the finished floor. This lighting must be achieved using long lasting fluorescent lamps. Ceiling lights must be fused on a separate breaker and be provided with a switch located immediately inside the access door to each room.
D. WALL AND FLOOR PREPARATION: All telecommunications room (IDF) walls must be affixed with plywood Backboards as specified on the "T" series drawings. The Backboards will cover from the finished floor to a height of eight feet (8') or to the ceiling, whichever is lower. Due to dusting characteristics of concrete, all such interior surfaces should be painted or tiled and finished in a light color to increase illumination. Paint should be free from turpentine. Telecommunications rooms will not be carpeted. There should be a minimum floor load rating of 2.4 kPa (50lb/ft sq).

3.2 INSTALLATION

A. Comply with NECA 1.
B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
C. Revise two paragraphs below to specify coordination with other parties involved in finalizing communications equipment room work. See Editing Instruction No. 3 in the Evaluations.
D. Coordinate layout of all Telecommunication Rooms with the "T" Series Drawings
E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate with the requirements on the "T" Series Drawings

3.3 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Fire stopping."
B. Comply with BICSI TDMM, "Fire stopping Systems" Article.
C. Sleeves through fire rated partitions shall be HILTI 653 speed sleeves no exceptions

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
B. Comply with requirements in Section 260526 "Grounding and Bonding For Electrical Systems"
C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 6 AWG Grounding Electrode Conductor from grounding bus bar to suitable electrical building ground.
D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment Bonding Conductor (BC).Retain subparagraph below if screened twisted-pair cables and coaxial cables are in communications equipment rooms.
E. The Entrance IDF (Telecommunications Room) must be equipped with a TMGB (Telecommunications Main Grounding Bus bar) which is grounded to the main electrical service ground for that building, at a single point only (Figure 7) using a Grounding Electrode Conductor. The TMGB shall NOT be grounded to electrical conduits, power distribution box grounds or neutral busses.
F. In the Entrance IDF all of the following must be bonded with a BC back to the TMGB:
   1. The vault splice closure for the entrance telephone cable
   2. The telephone building protectors
   3. All metallic conduits
   4. All data relay racks
   5. All other IDF's must be equipped with a TGB (Telecommunications Grounding Bus bar) which are bonded to the nearest IDF or Entrance IDF (Figure 8). The BC (Bonding Conductor) shall consist of at minimum, a green insulated, copper conductor which shall interconnect all equipment rooms.
G. In all IDF's the following must be bonded with a BC back to the TGB:
   1. All metallic conduits
   2. All data relay racks
H. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's labelSee Section 271500 "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section.
I. Labels shall be preprinted or computer-printed type.

END OF SECTION 27 1100

SECTION 27 1116

CABINETS, RACKS, FRAMES AND ENCLOSURES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install equipment cabinets, racks, frames and enclosures for the support, housing, protection, etc. of communications equipment as indicated on the Drawings, Specified or as otherwise required.
B. Reference Schedules on Drawing T3.00 for Additional Requirements

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Open equipment racks shall be 19" wide (20.25" O.A.) x 84" high, with 1.265" x 6.0" OVERSIZED side channels (0.19" flange x 0.13" web thickness min.), dual 4" x 6" x ¼" extruded aluminum base angles dual 1½" x 1½" top angles, No. 12-24 rolled thread panel mounting holes in both flanges, universal 5/8 – 5/8 – ½ hole pattern, 45 rack mounting spaces, 6061-T6 structural grade aluminum, black powder coat finish, meets EIA-310E Standards, Ul1863 listed, complete with fifty (50) No. 12-24 pilot point, phillips/slotted head mounting screws. All parts for open equipment racks are to be from the same manufacturer.
   1. Acceptable manufacturers are:
      a. Chatsworth
B. Preferred acceptable manufacturer for freestanding cabinets
   1. Chatsworth Terra-frame
C. Reference the equipment schedule on drawing T3.00 for cabinet, rack, and cable management specifications.

PART 3 EXECUTION

3.1 INSTALLATION

A. Wall mounted cabinets shall be mounted on ¾" AC grade or better void free plywood backboard.
   1. The Grade "C" surface will be facing the wall. Fire proofed and painted to match the existing wall where cabinet is to be mounted.
   2. Contractor to securely mount the backboard to the structural studs or masonry structure and provide blocking as required.
   3. Unless noted otherwise, the plywood backboard shall be installed flush on the finished drywall, block or concrete wall, securely anchored to the building structure.
   4. Where applicable backboard and wall mounted cabinets shall be mounted to the blocking, "T-Nuts" shall be utilized on the backside of the backboard for cabinet mounting in the absence of blocking, metallic expansion anchors shall be utilized in concrete and masonry construction.
   5. Plastic anchors, moly-bolts, etc. are not acceptable.
   6. The backboard shall match the outline of the wall mounted equipment cabinet as closely as possible, to minimize the exposed backboard distracting from the visual appearance of the

installation.

B. Equipment racks, cabinets and enclosures shall be installed per the manufacturer's recommendations and instructions, utilizing manufacturer's accessories and components. Contractor fabricated components shall be utilized only with the Owners and Engineers written approval.

C. The Contractor shall provide and install equipment and materials in the equipment racks as per the detailed Engineering Drawings and documents. Additional equipment racks shall be provided as indicated on the Drawings and documents for the installation and mounting of Owner furnished equipment and/or as otherwise indicated.

D. The free standing distribution equipment cabinets shall be provided and installed as indicated on the detailed Engineering Drawings and documents, for the housing of materials and equipment where such materials and equipment must be enclosed and secured for appearance and/or security purposes. Free standing distribution equipment cabinets shall be double (front and back) accessible with provisions for adjustable 19" rack mounting rails and accessories.

E. The wall mounted distribution equipment cabinets shall be provided and installed as indicated on the detailed Engineering Drawings and documents for the housing of materials and equipment, in such locations as where space for such equipment and material is limited, a controlled environment is limited, security and protection of the equipment is required. Wall mounted distribution equipment cabinets shall provide 19" rack mounting on a swing fame for double (front and back) access to equipment on the 19" frame and access to equipment mounted on the back panel.

F. The distribution equipment rack frames shall be securely anchored to the floor, using anchors into the concrete floor, or toggle bolts through raised floors as per the manufacturer's recommendations and instructions. When specified on the Engineering Drawings and documents or otherwise required, the Contractor shall provide and install "raised floor rack support" kits for the installation of distribution equipment racks on raised floors. The tops of the distribution equipment racks shall be securely tied together and braced from the wall from behind or from structural steel from above. There shall be no movement of the racks.

G. Free standing cabinets shall be securely anchored to the floor at all four (4) corners, using anchors into the concrete floor, or toggle bolts through the raised floors as per the manufacturer's recommendations and instructions. Wall mounted cabinets and wall mounted racks shall be securely mounted to the walls as required. The Contractor shall provide for the installation of special blocking and bracing as required between studding in the walls, etc. and shall provide additional bracing and support as required from the floor and/or ceiling structure above as approved by the Engineer and Owner.

H. Distribution equipment racks and/or cabinets shall be laid out and located as indicated on the detailed Engineering Drawings and documents, with vertical cable organizers located between racks as indicated. All racks and cabinets shall be bonded to the data/ telecommunication grounding system. Patch panels, cable organizers, fiber interconnect cabinets, etc. shall be mounted in the racks and cabinets as indicated on the drawings. Discrepancies or conflicts shall be brought to the attention of the Engineer and Owner for resolution, before proceeding with the installation. Power strip installation, cable and cord routing on the equipment rack and/or in the equipment cabinet, shall not obstruct or restrict the mounting of rack mounted equipment or access to said equipment. The completed distribution equipment rack with installed equipment and/or the completed equipment cabinet with installed equipment shall be such, that there shall be complete unobstructed access to all equipment, components, cables, terminations, etc., without requiring the removal of one item to

gain access to another. Each item of equipment shall be removable from the rack or cabinet, without having to remove another piece. No mounting space in the rack or cabinet shall be made unusable by the inappropriate mounting of another component, item or cable routing. Distribution equipment racks and equipment cabinets shall be installed such as, to afford the maximum accessibility and working space in and around the equipment as indicated on the detailed Engineering Drawings. Any discrepancies or conflicts shall be brought to the attention of the Engineer and Owner prior to installation.

I. The power for the equipment racks shall be as indicated on the detailed Engineering Drawings and in Section 271126 Communication Systems Rack and Cabinet Mounted Power.

J. Power for equipment cabinets shall be as indicated on the detailed Engineering Drawings and in Section 271126 Communication Systems Rack and Cabinet Mounted Power.

K. Telecommunication Room layout guidelines and recommended perimeters are described and illustrated in the detailed Engineering Drawings.

L. Unless otherwise indicated, equipment racks and wall mounted equipment shall be installed such that a minimum of 42” clearance is available from all sides for installation and maintenance.

END SECTION 27 1113

SECTION 27 1119

TERMINATION BLOCKS AND PATCH PANELS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install termination blocks and patch panels for the termination, cross-connecting and inter-connection of copper and fiber optic cables as indicated on the Drawings, specified or as otherwise required.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.2 Copper termination angled patch panels shall be 19" rack mountable designed to accept four (4) or eight (8) six-port distribution modules with built-in horizontal patch cord management brackets on the front and rear cable management bar. Patch panels shall be available in twenty-four (24) and forty-eight (48) port configurations. Patch panels shall be Category 6 Angled Patch Panel Solution

1. 24 port patch panel
2. 48 port patch panel

2.3 Fiber Optic Enclosure; Rack Mounting in a 1U configuration will be used. See detailed prints for the required enclosures. Enclosures will be provided with all specified fiber adaptor panels

A. 1U Fiber Panel – Commscope Uniprise 760147439 | RFE-SLC-IS-EMT-BK/1U-PNL
B. Adaptor Panel – Commscope Uniprise 760067173 | PNL-BK-012-MFA-LC02-AQ-SHUTTERED

PART 3 EXECUTION

3.1 INSTALLATION

A. Where indicated on the Drawings and in the Contract Documents, 110 type cross-connect blocks, copper media patch panels and fiber optic media patch panels shall be provided by the Cabling Contractor.

B. Cross-connect blocks and patch panels shall be as specified or otherwise indicated.

C. Copper termination and fiber optic termination patch panels shall be provided and installed in the equipment racks and/or cabinets as per the detailed Engineering Drawings and documents.

D. The Contractor shall verify that all equipment and materials meet the Specifications and

descriptions. The Contractor shall be responsible for notifying the Engineer in writing if the vendor/manufacturer alters his product specification, description, part number, etc. Such notification shall be made in a timely manner such that changes may be properly evaluated and corrective measures implemented as required. Products, materials and equipment installed which do not meet the Specifications and/or product description will be replaced at the Contractor's expense.

E. Both copper and fiber optic media cables shall be terminated in alpha-numerical order on the designated patch panel per the installation spreadsheet provided by the IT Department.

F. Patch panels and cross connect blocks shall be terminated per the XXXX Cabling Installation Guideline document, except:
   1. Patch panels shall be terminated utilizing the rear access procedure with the distribution modules "locked" in place in the patch panel and providing minimum controlled slack. Front access termination of the patch panel is not acceptable.

G. Provide pre-printed labels as required. Hand written labels are not acceptable.

H. Fiber optic patch panels shall be located at the top of the equipment racks. Above normal eye level (6'-0") unless otherwise approved by the Owner and Engineer.

END SECTION 27 1119

SECTION 27 1123

CABLE MANAGEMENT AND LADDER RACK

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish and install a cable management system. Including cable ladder (runway), vertical organizers, interbay horizontal organizers, cable ties, etc. as indicted on the Drawings, Specified or as otherwise required.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Cable Ladder (Runway)
   1. Cable ladder shall be UL Classified as suitable as an equipment grounding conductor and be of tubular construction The ladder shall be installed as per the manufacturer's instructions, utilizing manufacturer's accessories and components.
      a. Acceptable Manufacturers
         1) Chatsworth
   2. Cable ladder shall be sized as specified on the "T" Series Drawings
   3. Ends shall have protective rubber or vinyl end caps provided.
   4. Cable ladder shall be supported at both ends utilizing factory made accessories and fittings.
   5. Intermittent supports shall be factory made shelf brackets when run along a wall or a threaded rod trapeze supported from above.
   6. 6" rack to runway supports shall be used where cable tray is above equipment.
   7. All cable ladder elbows, bends, tees, drop-outs, cross fittings, etc. shall be factory made.
   8. All locations where cables change elevation in the MDF, BDF or IDF rooms a factory manufactured cable runway radius drop or cable runway radius bend will be used to support the cable.

B. Vertical Cable Management
      a. Vertical cable organizers shall be as indicated on the "T" Series Drawings
         1) Chatsworth Evolution Series

C. Horizontal Cable Managers
      a. Horizontal cable managers shall be as indicated on the "T" Series Drawings
         1) Chatsworth Evolution Series

D. Cable Ties and Wraps
   1. Cable ties and wraps shall be of two (2) basic types:
   2. Hook and loop type (Velcro) cable wraps:
   3. ¾" wide roll stock material.
   4. Minimum 2" overlap.
   5. Available in plenum rating as required.

E. Hook and loop cable wraps shall be utilized for cable management in the horizontal only, not to be used for the support of cables in the vertical or under load.
   1. Nylon and Halar cable ties:
   2. Parallel entry ties required, except plenum rating.
   3. 0.190 width minimum.
   4. Available plenum rating as required.

F. Nylon and/or Halar cable ties shall be utilized for cable management and support in the vertical and under load.
   1. As Owner and Engineer approved equal.

G. Corrugated Loom Tubing
   1. Available in various inside diameters from 0.27" to 1.88", solid wall and split wall, colors- orange or black. Not plenum rated.
   2. Utilized to protect exposed communications cables (e.g. cables feeding partition furniture from wall or floor box).
   3. As manufactured by Panduit, Carlon, Tyton or Owner and Engineer approved equal.

H. Corrugated Inner Duct
   1. Shall be in 1-1/4"., solid wall or split wall, color – orange.
   2. Plenum and riser rated.
   3. Standard non-metallic and metallic adapters and couplings available.
   4. Available with pre-installed pull tape.
   5. Utilize for the protection of exposed fiber optic cables, the protection of fiber optic cables in conduits, j-hooks, or cable trays and the sub-division of large conduits to provide multiple paths for future use and ease the removal of cable in the future.
   6. As manufactured by Carlon or Owner and Engineer approved.

PART 3 EXECUTION

3.1 INSTALLATION

A. The cable ladder (runway) installation shall be as shown on the detailed Engineering Drawings and documents.

B. The cable ladder shall be supported from both ceiling mounted hardware or 6" stand-off brackets from equipment racks and cabinets where applicable.

C. The cable ladder system shall be bonded together and to the communication grounding system.

D. Cable ladders shall be as indicated on the Drawings

E. The Contractor shall furnish and install additional cable ladder per Specification as required to facilitate the communication cabling installation. The minimum installation is indicted on the Drawings.

F. Cable ladder installation shall be as per the manufacturer's recommendations and instructions, utilizing manufacturer's accessories.

G. All cable ladder and supporting unistrut and brackets shall be cleanly cut with an appropriate metal cut-off saw and be clean and free of all burrs and sharp edges.

H. The Owner and Engineer shall approve all fabrications.

I. The Contractor shall verify the cable ladder loading requirements and size the ladder and support system for 100% future growth.

J. The Contractor shall provide all end caps, tube caps, mounting spacers, couplings, hangers, brackets, drop outs, connectors, support braces and other manufactures accessories and components as required to provide a complete and functional installation.

K. Coordinate cable ladder layout, including the specific routing and mounting elevations with building structure and work of other trades. Provide additional elbows and fittings as required to facilitate changes in elevation of the cable ladder to avoid conflicts with building structure and work of other trades.

L. Cable ladders are for the installation of voice, data and CATV communications cables only. No other cables, including other low voltage cables for fire alarm, TCC/HVAC, etc. are permitted on the cable ladder.

M. All splice plates shall be installed in a manner to maintain the integrity of the cable ladder as an equipment ground conductor. Install bonding jumpers across all expansion joints and adjustable splice plates.

N. Install end plates on all cable ladders.

O. Ground all cable ladders with a No. 6AWG ground conductor to the telecommunications ground bus bar. Cable ladder shall not be utilized as an equipment grounding conductor or means.

P. Conduits attached to the cable ladder shall be secured with approved conduit clamps and bonded.

Q. Cable ladder carrying low voltage cables should be kept a minimum of 12 inches away from lighting fixtures and ballasts.

R. Provide wall mounted vertical cable ladders from the floor sleeves to overhead cable ladders, or overhead sleeves to the horizontal cable ladder.

S. Vertical cable managers shall be installed between adjacent communications equipment racks and on each end of the row of equipment rack as shown on the Engineering Drawings.

T. Vertical organizers shall be installed with the hinged cover installed in place.

U. Hook and loop type cable wraps shall be utilized for organizational purposes on horizontal cable runs only. Hook and loop type cable wraps are not acceptable for providing vertical cable support.

V. Where data/telecommunication cables are routed in an open ceiling distribution system or routed on cable tray, channels and ladders or routed through surface mounted raceways and/or wireway, cables shall be separately bundled in groups of twelve (24) cables as described below

W. Data, telephone, and CATV cables are to be separately bundled as required to maintain a neat and orderly installation. Data, telephone, and/or CATV cable bundles may be supported in the same or separate hangers. Cables within the bundles shall be straight and parallel, free of twists, tanglements, kinks, knots, etc. Cable supports shall not pinch, bind, crimp or in any way cause physical damage to the data/communication cables. Cables shall be free from tension at both ends and for the entire length of the cable. In cases where a cable or cables must bear some stress (e.g. vertical risers, etc.), "Kellem" grips shall be used to distribute the strain over a longer length of the cable(s). All vertically routed cables shall be neatly bundled and supported on a vertical cable ladder or rings, by means of velcro on 24" centers or as directed.

END SECTION 27 1123

SECTION 27 1126

RACK MOUNTED POWER REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Contractor is to provide and install the APC-AP9560 horizontal power strips specified on the Nema/Equipment schedule on drawing T3.00
B. The Contractor is to Install Owner Provided Zero U equipment rack mounted power equipment, indicated as "Owner Provided" on the Nema/Equipment schedule on drawing T3.00.

PART 2 PRODUCTS AND EQUIPMENT

2.1 RACK AND POWER DISTRIBUTION

A. The Cabling Contractor Shall install Owner-Provided Rack or Cabinet mounted power distribution modules as specified on the "T" Series Drawings
B. The Contractor shall provide and install Vertical PDU Brackets for owner provided PDU's
C. The Contractor shall provide and install the APC-AP9560 Horizontal 1U PDU's as identified on drawing T3.00

PART 3 EXECUTION

3.1 INSTALLATION

A. Install rack mounted power protection equipment as indicated on the Drawings or otherwise indicated on the Contract Documents.

END SECTION 27 1126

SECTION 27 1500

HORIZONTAL CABLING SYSTEMS

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. Requirements of the following Division 27 Sections apply to this section:

C. Division 27 Section 27 0100 “Basic Communication System Requirements”.

D. Division 27 Section 27 0500 “Common Work Results for Communications”.

1.2 SUMMARY

A. This Section includes copper cables and jacks designed and used for voice/data networks.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.

B. Submittals shall be made as complete systems including all required accessories and special installation tools (i.e. termination hardware).

C. Product information including the following cable transmission characteristics:

1. Insertion Loss
2. Near-end Crosstalk (NEXT)
3. Power Sum Near-end Crosstalk (PS NEXT)
4. Attention-to-Cross Talk Ratio (ACR)
5. Power Sum Attention-to-Cross Talk Ratio (PS ACR)
6. ELFEXT
7. Power Sum ELFEXT (PS ELFEXT)
8. Return Loss
9. Skew
10. LCL

D. Manufacturers complete installation instructions including, but not limited to, the following information:

1. Minimum bend radius
2. Maximum pulling tension
3. Recommended installation of pulling points (i.e. every 270 degrees of bends in the conduit, or every 150 feet of raceway)

E. Provide information regarding all terminations that will be required to complete this installation. This information shall include complete specifications and installation instructions.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code."

B. Toxicity: Comply with applicable codes and regulations regarding toxicity of combustion products of materials used in voice/data cables.

C. UL Compliance: Comply with applicable requirements of UL Standard 910 "Test Method for Fire and Smoke Characteristics of Cables Used in Air Handling Spaces." Provide products that are UL-listed and labeled for such use.

D. Comply with the following Electronic Industries Association (EIA) and Telecommunications Industry Association (TIA) Standards:

1. TIA/EIA-568-B, "Commercial Building Telecommunications Wiring Standard"
2. TIA/EIA-569-A, "Commercial Building Standard for Telecommunications: Pathways and Spaces"
3. TIA/EIA-570, "Residential and Light Commercial Telecommunications Wiring Standard"
4. TIA/EIA-606-A, "The Administration Standard of the Telecommunications Infrastructure of Commercial Building"
5. EIA Standards EIA-230, "Color Marking of Thermoplastic Wire" and
6. EIA-258, "Semi-Flexible Air Dielectric Coaxial Cables and Connectors, 50 Ohms."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver cable factory-packaged in containers or reels. Store in clean dry space and protect products from damaging fumes and traffic. Handle wire and cable carefully to avoid damage.

PART 2 PRODUCTS

2.1 UNSHIELDED TWISTED PAIR (UTP) VOICE/DATA CABLE AND JACKS

A. General: Provide unshielded twisted pair cable of manufacturer's standard materials as indicated on the drawings. All cables shall be designed and constructed as recommended by the system/equipment manufacturer, for a complete installation and for applications indicated.

B. Manufacturers: All cable and connectors for the voice/data system shall be provided in compliance with the warranty requirements of section 27 01 00.

C. Manufacturers: Subject to compliance with requirements, provide unshielded twisted-pair cabling products and connectivity products of one of the following:

D. Connectivity/Cable:

1. Commscope Uniprise Cat 6 Cable

E. Provide where indicated on the Drawings or where required by the Specifications, standard

TIA/EIA Category 3 unshielded twisted pair cable complete with jacks.

F. Provide plenum rated cable in all areas having plenum rated ceiling. All areas of the building shall be considered as having plenum rated ceiling unless noted otherwise on the Drawings.

G. Category 3 UTP cable shall meet the following requirements:

1. Provide the 25 pair cables as indicated on the drawings.
2. Manufacturer/Model Number: Provide cable manufactured by one of the following companies:
3. Manufacturer not specified

H. Terminate jacks and Patch Panels:

I. All jacks shall be RJ-45, 568B configuration.
J. Patch Panel shall be angled in 24 or 48-port configuration as required by the number of workstation cables (plus 20%).
K. Manufacturer/Model Number: Provide jacks manufactured by Commscope Uniprise

2.2 Category 6 Voice/Data UTP Cable:

A. Provide where indicated on the Drawings or where required by the Specifications, enhanced TIA/EIA Category 6 unshielded twisted pair cable.
B. Provide plenum rated cable in all areas having plenum rated ceiling. All areas of the building shall be considered as having plenum rated ceiling unless noted otherwise on the Drawings.
C. Cable/connectivity "channel link system shall be certified by a third part, such as ETL.
D. Category 6 UTP cable shall meet the following requirements:

1. Structured cabling system shall support 1GB Ethernet.
2. All cables shall have 4-pairs with a pair separator built into the cable.
3. All Category 6 cables shall meet the minimum requirements of the TIA/EIA-568B.2-1 Category 6 and ISO 11801 2 Edition Class E channel standards.

2.3 Manufacturer – Commscope Uniprise Cat 6 Plenum UTP

2.4 Jacks and Patch Panels:

1. All jacks shall be RJ-45, 568B configuration. Reference the "T" Series drawings for colors
2. Patch Panel shall be angled in 24 or 48-port configuration as required by the number of workstation cables plus 20%.
3. Manufacturer/Model Number: Provide jacks and patch panels manufactured by the following Manufacturer:
   a. Commscope Uniprise

PART 3 EXECUTION

3.1 INSTALLATION OF VOICE/DATA CABLES

A. Voice/data cables shall be installed with a minimum 18" clearance from light fixtures, electrically operated equipment and all wiring operating at 120 or more volts.

B. Voice/data cables shall be installed in accordance with manufacturer's written instructions and in compliance with NEC.

C. Coordinate installation with other Work.

D. Install without damaging conductors or jacket.

E. Do not, either in handling or installation, bend cable to smaller radii than minimum recommended by manufacturer.

F. Ensure that minimum manufacturer's recommended pulling tensions are not exceeded.

G. Pull conductors simultaneously where more than one is being installed in same raceway. Use pulling means, including fish tape, cable, rope, and basket weave wire/cable grips that will not damage media or raceway.

H. Install all cable parallel and/or perpendicular to building surfaces or exposed structural members, and follow surface contours where possible. In ceiling cavities, install cables at bottom of trusses.

I. Provide "J" hooks for all cables not installed in raceways. "J" hooks shall be spaced no greater than five feet (60") on center, with a maximum spacing of four feet (48") for bundles of 20 or more cables. Do not exceed manufacturer's capacity for "J" hooks.

J. No cable splices are allowed.

3.2 TERMINATIONS

A. Terminations at the RJ-45 voice/data jacks shall be made in accordance with TIA/EIA Standard T568B.

3.3 ROUTING

A. Provide adequate length of conductors within boxes at workstation end. Leave sufficient cable length within box to allow for easy removal of faceplate and devices. At the workstation end, leave 10' of excess cable above finished ceiling, directly above voice/data outlet, coil excess cable in a 10" loop with four tie wraps.

B. Provide adequate length of conductors at patch panels and at punch down blocks. Leave sufficient cable length so that cables can be trained vertically down ladder rack and vertical wire management accessories without cables being tight. All cables shall be secured with Velcro straps every 12" on center on the rack/cabinet and the ladder racks. Tie wraps shall not be acceptable within IDF or MDF Rooms.

3.4 FIELD QUALITY CONTROL

A. Prior to usage, test each cable for electrical continuity, short circuits, length, mapping and pairing, attenuation, return loss, NEXT, PSNEXT, ACR, PSACR, ELFEXT, and PSELFEXT.

B. Test all cable segments for faulty connectors, terminations, and the integrity of the cable and its component parts.

C. System Certification Testing

1. Test the entire cabling system in accordance with the termination manufacturer's warranty program. Warranty programs are specified in section 27 01 00.
2. Coordinate this testing with the Architect and Engineer. Notify both the Architect and Engineer at least seven days in advance of testing in order for the Architect and Engineer to make plans to witness this testing.
3. After all punchdowns and cable terminations are complete test each cable from the workstation outlet to the patch panel. Perform both channel and link tests.
4. This testing shall be conducted with a LAN Tester, as manufactured by Microtest, Wavetek, or as approved by the cable/termination manufacturer.
5. Measure and record the following data: mapping and pairing, attenuation, return loss, NEXT, PSNEXT, ACR, PSACR, ELFEXT, and PSELFEXT.
6. Document the test results in graphic plot/text format immediately following the testing.

I) Documentation shall be in printed form, 8½" x 11" paper printed via a laser printer. Provide two copies of the recordings bound in two separate cable record books, indexed for easy reference and transmit these books to the Architect for review by the Engineer. Bind the original recordings in a cable record book indexed for easy reference during future maintenance operations and turn book over to the Owner's authorized representative.

3.5 COMMISSIONING

A. Subsequent to installation of voice/data cable and equipment demonstrate proper functioning. Replace malfunctioning components with new materials, and then retest until satisfactory performance is achieved.

END OF SECTION 27 1500

SECTION 274100

AUDIO-VIDEO SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Work of this Section Includes: Furnishing and installation of specified products with all required accessories and related cabling/wiring, supervision, coordination, software programming, testing, documentation and instruction to provide complete and properly functioning audio-video systems. Section corresponds to 'AV' series of the Drawings.

B. Products Furnished But Not Installed Under This Section: Floor boxes, loudspeaker back boxes, junction boxes and NEMA enclosures indicated on the 'AVE' and systems design and details on the 'AV' series drawings.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3 REFERENCES

A. Electronics Industries Association (EIA)

B. National Electric Code (NEC)

C. Society of Cable Telecommunications Engineers (SCTE)

D. Society of Motion Picture and Television Engineers (SMPTE)

E. Telecommunications Industries Association (TIA)

F. Audiovisual Best Practices: The Design and Integration Process for the AV and Construction Industries, 2005, by Tim Cape & Jim Smith; published by InfoComm International

G. Basic Principals for Suspending Loudspeaker Systems, JBL Technical Notes V1, NO. 14

H. Handbook for Riggers, 1989 Revised Edition, W.G. Newberry; published by Newberry Investment Co.

I. Sound System Engineering, Second Edition, 1986, by Don & Carolyn Davis; published by Howard W. Sams & Co.

1.4 SUBMITTALS

A. Refer to requirements in Division 01 for scheduling and quantities of submittals. Include one additional copy of each submittal beyond the general requirements of Division 01.

B. Submit all product data and shop drawings together in one package and receive approvals prior to ordering products.

C. Product Data:

1. Submit catalog data sheets, neatly bound with tabbed dividers between sections. Include a title page and space for submittal stamps.

2. Provide a list of all products in the same order that they appear in the Specifications with each product cross-referenced to Specification paragraph and equipment type or name used in the Specifications and Drawings. Identify all approved substitutions.

3. Submit a schedule of finishes indicating proposed materials and colors for all exposed items, subject to Architect's approval.

4. Submit a list showing coordination of selected frequencies for all wireless transmitters.

D. Shop Drawings:

1. Provide plans and reflected ceiling plans at a scale of not less than 1/8" = 1' and provide details at a scale of not less than 1/4" = 1’.

2. Submit system plans showing all device locations. Indicate transformer wattage taps for 70 volt distributed loudspeaker layouts.

3. Submit conduit riser diagrams showing connection of all devices and required conduit sizes with types and quantities of cables to be used and cable identification tags.

4. Submit point-to-point wiring diagrams and typed wire lists identifying every connection and type of connector. Include electronic devices such as switches, transformers and terminal blocks. Indicate locations of all components. Identify all wires and cables by type, color and wire number.

5. Submit rack layouts indicating the proposed arrangement of rack-mounted equipment including cable supports, junction boxes and conduit penetrations.

6. Submit fully dimensioned construction details of all panels, wall plates, floor box device plates and other custom fabricated items or modifications (e.g., integration of AV equipment in furniture). Include complete parts lists. Indicate finish materials and color selections, subject to Architect’s approval. Include schematic diagrams if custom electrical or electronic circuitry is involved.

7. Submit details for all projection systems showing overall system geometry with projectors and screens in full plan view, front elevation and side elevation, projection distances and lens selections as well as details of mirror assemblies where applicable.

8. For all items mounted overhead, submit mounting and support details complete with parts lists and dimensions. Include full plan view, front elevation and side elevation

of each item with corresponding support structure and mounting hardware. Verify load ratings of all hanging components including attachment hardware. Details shall be signed and sealed by a structural engineer registered in the State of Florida.

E. Source Quality Control Submittals: Prior to delivering products and pre-fabricated rack assemblies to the project site, submit specified 'source quality control tests' for approval.

F. Field Quality Control Submittals: Prior to the date of Substantial Completion and before scheduling Consultant's testing / adjusting / punch list site visit, submit all specified 'field quality control tests' together in one bound volume for approval.

G. Closeout Submittals:

1. Record Drawings: Maintain a full set of shop drawings at the project site annotated to indicate actual equipment and device locations, wattage tap settings and, in general, the true state of the installation. Prior to Substantial Completion, furnish one initial set of record drawings along with the results of all 'source quality control tests' and 'field quality control tests' to the Architect's Consultant for use during acceptance testing and adjusting. After approval of record drawings, submit full size prints and CAD files on CD-ROM in the submittal quantities required by Division 01 plus one additional copy for the Architect's Consultant.

2. Manuals: Furnish one initial set of equipment operation manuals to the Architect's Consultant for use during acceptance testing and adjusting. At the time of contract closeout, submit the system Operation Manual and Maintenance Data Manual, each bound with tabbed dividers between sections and including a title page with space for submittal stamps.

a. Operation Manual:

1). Table of Contents.

2). Typed description of each system including key features and operational concepts such as remote control features and functionality, switching and routing functions, patch points, mixing and linking capabilities.

3). Setup diagrams and typed instructions for use in typical situations as directed by the Owner or Architect's Consultant.

4). Small scale plans showing locations and circuit numbers for all system outlets and receptacles.

5). Single-line block diagrams showing interconnections of all major system components.

6). Two sets of 'A' size drawings showing the components and wiring in each individual rack. Locate one set in the manual. Attach the other copy of each rack drawing to the rear door of the associated rack in a plastic jacket.

7). Manufacturer's operation manuals for all user-operated equipment such as

mixing consoles, effects units, audio/video tape decks, DVD or Blu-ray Disc players, cameras, intercom equipment, etc.

8). Properly licensed working copies of the latest version of all software required to operate or configure the systems. Software shall be included in its "installable" state on CD-ROMs or USB drives. Include full software documentation. Additionally, provide any firmware and hardware required for configuration, adjustment, diagnosis and repair. All user definable software configurations and programming shall become the sole property of the owner. This includes compiler, source code, source code copyrights and related documentation.

9). Key schedule cross-referencing all keys to their respective functions.

b. Maintenance Data Manual

1). Table of Contents.

2). Company name, address, telephone number and contact name for system service or maintenance.

3). Alphabetical manufacturer listing for all products specified in this Section along with manufacturers' addresses and telephone numbers.

4). Listing of all installed products with model or part numbers, categorized by manufacturer (in alphabetical order).

5). Catalog data sheets for all installed products.

6). Manufacturers' warranties and a typed one-year system warranty explicitly covering all materials and labor, notarized after system acceptance.

7). Approved Source Quality Control and Field Quality Control submissions along with results of final tests and adjustments performed as part of system commissioning.

8). Recommended preventative maintenance schedule with reference to applicable pages in manufacturers' maintenance manuals. If a manufacturer does not give inadequate information, provide the information necessary for proper maintenance.

3. Electronic Closeout Submittals:

a. Submit CD-ROMs containing all electronic files used in producing the hardcopy Closeout Submittals above. Include a master file list in text format on each CD ROM with a short description of files on that disk.

b. Provide word processing files in MS Word 2010 or later version. Provide tables, graphs and charts in MS Excel 2010 or later version. Include any graphic images necessary for the reproduction of the submittals in JPEG (.JPG) file format.

Provide drawing files (.DWG) in AutoCAD R2013 or later version. Drawing Exchange Files (.DXF) are not acceptable. Include all XREFs, fonts and other drawing parts necessary to view or plot the drawings.

4. Keys: Submit in triplicate all keys required for access to and operation of the systems.

1.5 QUALITY ASSURANCE

A. Installer Qualifications

1. Refer to Procurement and Contracting requirements as outlined in Division 00.

B. Submit a statement that the bid is based upon specified products or substitutions accepted by the Architect's Consultant during the bid phase.

C. Submit with bid, an annually renewable Service and Maintenance proposal for systems specified in this Section. If accepted, the Service and Maintenance contract shall commence upon conclusion of the one-year system warranty.

1.6 WARRANTY

A. Provide 'system' warranty against faulty materials and defects in workmanship for a period of one year after system acceptance. In addition to this one-year 'system' warranty, honor any longer-term manufacturer warranties on installed products.

B. During one-year 'system' warranty period, answer service calls and requests for information within 24 hours. Repair or replace faulty materials and correct faulty workmanship within 72 hours of call from Owner or building management office.

PART 2 PRODUCTS

2.1 MICROPHONES

A. Digital Conferencing System - Digital Conferencing Public Meeting Digital Conference System is a core system expandable to accommodate 1,024 microphone units and can support up to 8 open microphones. The System may be used for many types of applications, from simple discussion or parliamentary voting to simultaneous interpretation. The System supports 4 languages as a standard, but can be configured for up to 28 languages with the addition of feature licenses (Floor+8, Floor+28). The System can be configured and managed via a PC connected to a LAN using the included CoCon Meeting Software Suite. Approved Product:

1. Listen Technologies / Telvec Confidea:
   a. Central Unit: Confidea CU
   b. Port Expander Unit: Confidea SPL5525
   c. Software: CoCon Meeting Suite with interface for Granicus
   d. Chairman Desktop Station with Voting: L-CV-C
   e. Delegate Desktop Station with Voting: L-DV-C
   f. Delegate Desktop Station without Voting: L-DD-C

g. Delegate Flush Station without Voting: FC-M-XLW w/ MIC38L Microphone
2. As Approved

B. Wireless Microphone System, Type 1 - 24 bit digital audio wireless microphone system with interchangeable lithium ion battery system and advanced encryption. Network control. Approved Products:

1. Shure Audio:
   a. Dual Receiver: ULXD4D
   b. Antenna: PS805 Wide Band Wireless Antenna (2 Per Dual Receiver)
   c. Body Pack Transmitter: ULXD1/xxx Bodypack (1 Per Dual Receiver)
   d. Lavolier Microphone: MX150B/C-TQG Lavolier Microphone (1 Per Dual Receiver)
   e. Headworn Microphone: WH30TQG Cardiod Headworn Microphone (1 Per Dual Receiver)
   f. Handheld Microphone ULXD2/B58 Handheld Digital Wireless Microphone (2 per dual receiver unit)
   g. Rechargeable Batteries: SB900 Transmitter Lithium-ion Battery (4 per dual receiver unit)
   h. Battery Charger: SBC800-US 8 Bay Battery Charger (1 Total)
2. As Approved

C. Microphone Stands - Round bottom stand with accessory boom. Approved products:

1. Atlas:
   a. MS-12CE Stand (Qty 4)
   b. PB11XR Telescoping Boom (Qty 4)
2. As approved

2.2 PROGRAM SOURCES

A. Assistive Listening System (ALS) – Hearing assistance system that meets the minimum requirements of the 2010 Americans with Disabilities Act (ADA) standards for accessible design for venues of 50 to 250 seats. The system can be ordered only on the 72 MHz frequency band, and can be customized if you need additional parts. Approved products:

1. Listen Technologies
   a. RF Transmitter
      1). LT-800 with LA-326 Rack Mount Kit
   b. RF Receiver Package
      1). LR-40-072 Receiver bundle consisting of:
         a). LR-4200.072-1 Portable Digital RF Receiver (6 Total)
         b). LA-166 Neck Loop (6 Total)
         c). LA-330 Lanyard (6 Total)
         d). LA-164 Ear Speaker (6 Total)
         e). LR-381-01 Intelligent Charging Station (1 Total)

c. Antenna
   1). LA-122 Remote Antenna Kit
d. Accessories
   1). LA-304 Notification Sign

2.3 DIGITAL SOUND PROCESSORS

A. Audio Mixer, Type 1 – 10 input 2 buss analog audio mixer with simple slider control. Approved Products:

1. Behringer Xentx 1002B
2. As Approved

B. Digital Audio Processor, Type 1 and 2 - Open Architecture fully configurable digital signal processing platform RS-232 controllable. Input and output cards in banks of four channels either in analog audio or in AES/EBU digital audio. Approved Products:

1. BSS Audio:
   a. Type 1: Soundweb BLU-160
   b. Type 2: Soundweb BLU-120
   c. Analog Input Card (As required)
   d. Analog Output Card (As Required)
   e. Digital Output Card (As Required)
2. As Approved

2.4 AUDIO AMPLIFIERS

A. Audio Amplifier, Type 1 - Two Channel DSP Enabled and Remote Load Monitoring amplifier with 1200 watt output per channel into 4 ohm and 800 watt output per channel into 2 ohm impendence speaker load, AES/EBU Digital input in addition to analog inputs. Approved Products:

1. Labgruppen IPD 2400
2. As Approved

B. Two Channel Audio DA, Type 1 - Two input by 16 output (2x8 output) analog audio distribution amplifier. Approved products:

1. RANE DA 216S
2. As Approved

C. Audio Isolation Transformer, Type 1 - Dual 10k ohm 1:1 line isolation transformer capable of signal levels upt to +26 dBu. Approved Products:

1. RANE LT22
2. As Approved

2.5 LOUDSPEAKERS

A. Speaker, Type A - 6" Dual Concentric full range flush fitting ceiling speaker assembly

with 16 ohm impendence permitting four speaker to be connected in parallel and suitably powered by commercial amplifiers at low impendence outputs. Grill assembly paint-able when using speaker protection paint mask. Approved products:

1. Tannoy CMS601DC BM (Next Generation Version) with plaster ring or ceiling tile frame as required
2. As Approved

B. Speaker, Type B - 5" Dual Concentric full range flush fitting ceiling speaker assembly. Grill assembly paint-able when using speaker protection paint mask. Approved products:

1. Tannoy CMS501DC with plaster ring or ceiling tile frame as required
2. As Approved

C. Soundbar Speaker, Type 1 - Approved products:

1. JBL SB300 with:
   a. Custom Wall Bracket
   b. RDL PF-PA18H
2. As Approved

D. Control Room Monitor – 2-way 6" Dual Concentric surface mount wall speaker with mounting bracket. Approved products:

1. Tannoy Di 6 DC with K-Ball mounting bracket
2. As Approved

2.6 VIDEO INTERFACES

A. HDMI to UTP Transmitter, Type 1 - HDMI and Analog VGA converted to digital video over shielded CAT-6 cable. Approved products:

1. AMX AVB-TX-MULTI-DXLINK
2. As approved

B. UTP to HDMI Receiver, Type 1 - Digital video over shielded CAT-6 cable to HDMI receiver. Approved products:

1. AMX AVB-RX-DXLINK-HDMI
2. As approved

C. HDMI to SDI Converter, Type 1 - HDMI to SDI 4K to convert from HDMI devices to SD, HD, 3G and 6G-SDI video in SD, HD and Ultra HD video formats. Allows embed SDI audio from HDMI, AES/EBU or balanced analog audio inputs. Approved products:

1. Blackmagic Mini Converter HDMI to SDI 4K
2. As approved

D. SDI to DVI Converter, Type 1 - SDI to HDMI 4K to convert from SD, HD, 3G and 6G-SDI video sources to HDMI in SD, HD and Ultra HD video formats. De-embing of SDI audio to HDMI, AES/EBU or balanced analog audio out. Approved products:

1. Blackmagic Mini Converter SDI 4K to HDMI, With DVI Adapter
2. As approved

E. Sync Generator – Approved Product:

1. Blackmagic Mini Converter Sync Generator
2. As approved

2.7 VIDEO CAMERAS

A. Commission Chambers PTZ Camera, Type 1 – 1/3" CCD 1.3 Megapixel 16:9 format camera with 20x Optical Zoom with IP and RS-422 control, HD-SDI output. Approved Products:

1. Panasonic AW-HE120K with
   a. Vaddio 999-2225-016 in Wall Enclosure
2. As approved

B. Document Camera – 1/3" CCD 1.3 Megapixel 16:9 format camera with 18x Optical Zoom with IR and RS-232 control, DVI/HDMI output. Approved Products:

1. Vaddio HD-18 Ceilingview Camera assembly with:
   a. HD-18 Camera
   b. IR Remote
   c. DVI/HDMI Quick Connect Interface
   d. Recessed Ceiling Installation Kit
   e. Custom Plenum enclosure
2. As approved

C. Conference Room 113 and 216 Video Conferencing, Type 1 – - High-definition video conferencing with natural communications up to 1920 x 1080 at 30 fps (1080p), with exceptional resolution even at lower data rates, high-definition content sharing, SIP protocol interfacing for variety for VOIP phone compatibility (voice conferencing). Approved products:

1. Polycom HDX7000 High Definition Conferencing System:
   a. HDX7000 Video Conferencing Codec
   b. Eagle Eye III HD Auto PTZ Camera (1 Total)
   c. HDX Microphone Array (2 Total)
   d. Vaddio camera shelf
2. As approved

D. Office / Small Conference Room Video Conferencing, Type 1 – Video conferencing with natural communications up to 1080p60, with exceptional resolution even at lower data rates, high-definition content sharing, SIP protocol interfacing for variety for VOIP phone compatibility (voice conferencing) Approved products:

1. Polycom RealPresence Group 500:
   a. RealPresence 500 Codec

b. Eagle Eye IV Camera
c. RealPresence Group Microphone Array
d. Remote
2. As approved

2.8 VIDEO SWITCHING AND CONVERSION

A. Video Switcher , Type 1 – Five HD-SDI / One DVI-I input production video switcher with camera controller providing HD-SDI and HDMI outputs for both program and preview. Camera select and camera positon presets for quick selection of standard shots without joystick operation with 3 axis/ 1 button hall effect joystick with twist handle zoom control. A TFT flat panel display interface that provides preview of each input as well as preview and program images with touchscreen interfacing to allow touch control. Approved products:

1. Vaddio ProductionVIEW HD-SDI MV with:
   a. 22” Multiview Tough Screen w/Base and Vesa mount.
2. As approved

B. SDI Matrix, Type 1 - Mixed Format Router with built in control panel. Includes advanced 6G-SDI permitting SD, HD, and Ultra HD video in same router. Approved products:

1. Blackmagic Studio VideoHub 20 x 20 with:
   a. Videohub Master Control
2. As approved

C. Digital Matrix Type 1 – Integrated modular media switching / control system that manages and distributes analog and digital audio and video including HDMI/HDCP, control and Ethernet. Easily integrate HDCP into system designs and enjoy hassle-free plug-and-play operation. Built in SmartScale® Technology on every output provides video that is perfectly scaled for each connected display. Approved products:

1. AMX Enova
   a. Frame: ENOVADGC16-ENC
   b. HDMI Input Card: AVS-ENOVADGX-VI-HDMI
   c. DVI Input Card: AVS-ENOVADGX-VI-DVI
   d. Digital Xport Input Card: AVS-ENOVADGX-VI-DLINK
   e. HDMI Output Board: AVS-ENOVADGX32-VO-HDMI
   f. DVI Output Board: AVS-ENOVADGX32-VO-DVI
   g. Digital Xport Output Card: AVS-ENOVADGX32-VO-DLINK
   h. Audio Insert/Extract: AVS-ENOVADGX-AUD-INS-EXT
2. As approved

D. Presentation Switcher, Type 1 – AV matrix switcher, scaler, analog to digital signal converter, twisted pair transmitter and amplifier with built-in professional grade audio processing. Approved products

1. AMX DVX-3156HD
2. As approved

2.9 VIDEO DISPLAYS

A. FPD Display, Type 1 (OFE) - Owner furnished 70" flat panel display. Contractor to provide mounting assembly and connections verify operation. Approved Product:

1. Recommended brands to Owner
   a. Sharp
   b. Panasonic
   c. LG
2. As approved

B. FPD Display, Type 2 (OFE) - Owner furnished 55" flat panel display. Contractor to provide mounting assembly and connections verify operation. Approved Product:

1. Recommended brands to Owner
   a. Sharp
   b. Panasonic
   c. LG
2. As approved

C. FPD Display, Type 3 (OFE) - Owner furnished 21" flat panel computer monitor. Contractor to provide mounting assembly and connections verify operation. Approved Product:

1. Recommended brands to Owner
   a. Sharp
   b. Panasonic
   c. LG
2. As approved

D. Rack LCD Display, Type 4 – HDTV television with capabilities of displaying 1080p signals via HDMI connections and through integrated tuner . Approved Product:

1. Samsung UN19D4003BD with Visa 75mm x 75mm mount on rack panel matching or exceeding height of display. Provide grommet pass through at connection locations for cable passage into rack.
2. As approved

E. Speaking Timer System – Programmable timer system with capabilities for Total Time, Sum-Up Time, Time Remaining, and Background Session Time. Program options include audio and visual cues. Multi-Master capability permitting timer control from

more than one location on system. Approved Product:

1. Limitimer:
   a. Timer Master (Type 1)- AV-2000
   b. Timer Display (Type 2) – PSL-20V
   c. Timer Controller (Timer Distributor) – PSL-PB18
   d. Timer Display (Type 3) – PSL-20VF
   e. Timer Display (Type 4)- ASL-4ND3BT
2. As Approved

2.10 CONTROL

A. Control Processor - Refer to Part 2.8 C for integrated processor.

B. Control Room Rack Mount Control Panel (Type 1) - 7” edge-to-edge capacitive touch glass pane with multi-touch capabilities with rack mount adapting panel. Approved products:

1. AMX MST-701L 7"Touch Panel, Wall Mount with AMX MSA-RMK-07 Touch Panel Rack Mount Adapter
2. As approved

C. Chambers, Conference Room 113 and 216 Control Panel (Type 2) – Dock-able 9” Touch panel with both Wi-Fi and one-way IR communication giving the user instant control of virtually any device facility. Approved products:

1. AMX MVP-9000 9" Wi Fi Wireless Touch Panel with MVP-TDS-9 tabletop docking station
2. As approved

2.11 ETHERNET NETWORK

A. AV Control Switch, Type 1 - 24 Port Managed Switch with power over Ethernet, 8.8 Gbps. Approved products:

1. Cisco SF200-24P 24/100 Managed Switch with:
   a. Middle Atlantic Cable Manager above or below unit.
2. As approved

B. AV Wireless Access Point, Type 1 - Wireless a/b/g/n 2.4 or 5 GHz Wireless Access point with single point setup Approved products:

1. Cisco WAP551
2. As approved

2.12 RF DISTRIBUTION

A. Modulator, Type 1 - Digital Cable Modulator with HD-SDI input and scaling to true MPEG-2 1080i stream to comply with RF distribution standards and no frame loss. RS-232 Controllable. Approved products:

1. Contemporary Research QMOD-SDI 1.5 HDTV with:
   a. Rack Mounting Bracket or Shelf
2. As approved

B. Combiner, Type 1 - Eight high level and one low level input active high isolation combiner with 860MHz bandwith and 3dBmV gain. Approved products:

1. Contemporary Research QCA9-33 with:
   a. Rack Mounting Bracket or Shelf
2. As approved

C. RF Amplifier, Type 1 - Amplified RF combiner that can switch between one or four inputs, with adjustable amplification up to 50 dB. Approved products:

1. Contemporary Research QDA4-45 display with:
   a. Mounting bracket
2. As approved

D. RF Taps - 5Hz-1000MHz Tap with return loss greater than 16db (5Hz - 1000MHz), tap to tap isololation greater than 25 db. Approved products:

1. Toner DCRG/TGT Series:
   a. Type 1 - Toner DCWRG-* or DCRG-*
   b. Type 2 - Toner TGT4-*
   c. Type 3 - Toner TGT8-*
2. As approved

E. RF Splitters - 5Hz-1000MHz Splitter with return loss greater than 16db (5Hz - 1000MHz), tap to tap isolation greater than 17 db. Approved products:

1. Toner XGVS Series:
   a. Type 1 - XGVS-2
   b. Type 2 - XGVS-4
   c. Type 3 - XGVS-6
   d. Type 4 - XGVS-8
   e. Type 5 - XGVS-12
2. As approved

2.13 CABLING

A. Refer to cable tables in drawings for reference standard of each cable type.

B. Cable Markers – Label all permanent wiring on both ends with approved permanent clip-on type markers similar to Grafoplast Wire Markers or approved sleeve type markers. Wrap-around adhesive labels will not be accepted unless completely covered with clear heat shrink tubing.

2.14 EQUIPMENT RACKS

A. Modular Equipment Rack - Free standing modular rack. Approved product:

1. Middle Atlantic WRK-44-32 with:
   a. Side Panels
2. As approved

B. Small Pedestal Equipment Rack - Approved product:

1. Middle Atlantic C5F1-D with:
   a. Finishing kit as approved by Architect
2. As approved

C. Verify the depth of each equipment rack prior to assembly to ensure that mounted equipment will fit completely inside with the rear door closed. Install all rack-mounted equipment and provide Source Quality Control Tests before delivery of equipment racks to the project site.

D. Provide engraved Lamicoid labels on the front and rear of all racks and rack-mounted equipment identifying the racks and equipment according to names or titles used in the shop drawings. Attach labels to racks in a neat, plumb and permanent manner.

2.15 CONNECTORS

A. Make all connections with accepted Phoenix Contact terminal blocks or accepted connectors specified or indicated on the drawings.

B. For XLR-type connectors not factory-mounted on equipment, wire according to IEC-268 with pin 2 hot (high), pin 3 low and pin 1 ground (screen or shield).

2.16 FABRICATION

A. Complete all custom fabrication work at the shop including pre-assembly and testing of racks and rack-mounted systems.

2.17 FINISHES

A. Choose finish materials and finish colors of all exposed and custom fabricated items and labels to blend in with the surroundings, as approved by the Architect.

B. For engraved plates, panels and pushbutton switches, use 1/8” block lettering unless noted otherwise. Use white lettering on dark surfaces. Use black lettering on light surfaces such as stainless steel or brushed aluminum.

2.18 SOURCE QUALITY CONTROL

A. Tests

1. After assembly of rack systems in the shop, measure and record the DC resistance between the rack ground bus bar and the chassis of all rack-mounted components.

Also measure and record the DC resistance between the rack ground bus bar and the signal common for all components.

2. Use a sine-wave signal generator, dual trace oscilloscope and dBm meter to measure and document the level, which produces clipping at each component input used in the system.

3. Using a +4 dBm sine-wave input, set controls of each component to produce a +4 dBm sine-wave output. Under these operating conditions (unity gain), note the presence of any waveform distortion, interference, or oscillations. Take corrective action to eliminate the anomalies and document the corrective measures.

B. Performance Verification

1. In the shop, photograph the interconnect wiring within racks including patch panels and grounding to show the overall quality of workmanship and compliance with the specified grounding procedures.

2. Submit the test reports and photographs to the Architect's Consultant before delivery of racks to project site.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturers' recommendations. Ensure that levels and impedances are properly matched between components.

B. Firmly and permanently attach electrical boxes, enclosures and permanent equipment to the building. Ensure that rigidly mounted equipment and devices are plumb and square.

C. Mount all equipment to be installed over public areas in a manner adequate to support the equipment loads with a minimum safety factor of five, using methods recommended in the referenced Handbook for Riggers and in Basic Principals for Suspending Loudspeaker Systems. Use attachment hardware with a minimum SAE Grade 5 load rating. Do not use formed eye bolts or lag screws for support of suspended equipment.

D. Rack Assemblies:

1. Install all rack mounted equipment with stainless steel 10-32 pan head machine screws with flat black plastic washers protecting equipment panel.

2. Provide rack slides for all rack-mounted equipment that requires side or top access for routine cleaning, adjustments or operation

3. Provide security covers with tamper-proof screw attachments for all non-user-operated equipment that has front panel controls. Install security covers at the conclusion of system acceptance testing during Substantial Completion.

E. Wireless Systems:

1. Ensure that all wireless systems operate on different frequencies from each other and from any other transmitters in the area.

2. Coordinate frequency selection for compatibility with local RF environment.

F. Wiring and Connection Practices

1. Where specific instructions are not given, perform all wiring in strict adherence to standard broadcast and AV installation practices as described in the referenced Audiovisual Best Practices and in Sound System Engineering.

2. Group all wiring into the following classifications by power level or signal type:

   a. Microphone Level: less than -20 dBm.
   b. Line Level Audio and DC Control Circuits: -20 dBm to +30 dBm.
   c. Speaker Level: greater than +30 dBm.
   d. Video/RF Circuits
   e. AC Power Circuits

3. Maintain a minimum six-inch separation between wiring of different level classifications wherever possible. Otherwise, cross them perpendicularly. Where wiring of different level classifications share a common enclosure or junction box, provide metallic isolation barriers to completely electrically separate wiring groups.

4. Neatly harness wires together within racks by power level classification using horizontal and vertical wiring supports as required. Rigidly support all wires within twelve inches of connection points.

5. Use only balanced differential inputs throughout all audio systems unless noted otherwise. Use approved transformers to convert all unbalanced inputs to balanced inputs. Output signals may be unbalanced if the inputs of subsequent devices are within the same rack. Otherwise use acceptable transformers to balance the outputs.

6. Exercise care in wiring to avoid damaging the cables and equipment. Use grommets around cut-outs and knock-outs where conduit or chase nipples are not installed.

7. Dress unused wire ends by cutting them off approximately one-half inch (½") past the wire jacket, folding them back over the jacket and securing them in place with heat-shrink tubing.

8. Before connecting to any equipment or devices, terminate all field wiring (except video, RGBS and RF lines) in wall-mounted terminal boxes located in each equipment room. Provide 10% spare terminals at each location. Label each terminal with a unique number.

9. Ensure that all crimp, punch-down and terminal block connections are solid and that no soldered connections are “cold.” Take care to observe proper polarity when connecting loudspeakers.

10. Observe consistent polarity in microphone and line level audio wiring throughout the

system wherever XLR or TRS type connectors are used as follows:

a. XLR Type Connectors

1). Positive = Pin 2
2). Negative = Pin 3
3). Common = Pin 1

b. TRS Type Connectors

1). Positive = Tip
2). Negative = Ring
3). Common = Sleeve

G. Grounding and Shielding

1. Mount and enclose all electrical and electronic equipment in metal enclosures or equipment racks. Use EMT type conduit for all wiring outside of equipment racks.

2. Mount equipment racks in a manner that provides electrical isolation from the building structure and from electrical raceways. Use flexible conduits and PVC fittings to provide insulated connections between equipment racks and the building electrical raceways.

3. Ground the chassis of all rack-mounted components in accordance with the Drawings. Measure and confirm that the D.C. resistance between each equipment chassis and the ground bus in its respective rack is no more than 0.01 ohms.

4. Ground the shields of interconnecting wires on one end only in accordance with the Drawings. Dress the unused opposite ends as described under Wiring and Connection Practices. Insulate the unused shield drain wires with appropriately sized black heat shrink tubing equal to Alpha FIT-221 series.

3.2 FIELD QUALITY CONTROL

A. General Tests

1. Before connecting any equipment to electrical power circuits, measure and record the AC voltages between hot, neutral and ground and verify correct outlet polarity. Verify, test and document correct and safe function of isolated ground power systems.

2. Determine the best sequence of energizing systems to minimize the risk of damage.

3. After successfully energizing the systems, make preliminary adjustments and document the settings of all controls, parameters of corrective networks, voltages at key interconnection points, gains and losses as applicable. Replicate the unity gain tests performed at the shop and document the absence of any waveform distortion, interference signals, or oscillations.

4. Upon completion of the system installation, perform the necessary adjustments and

balancing of all signals, amplifier gain and other level controls to ensure proper system operation.

5. Verify the performance parameters of systems and subsystems following established industry procedures. Document all acceptance testing, calibration and correction procedures described herein, being careful to include the following information:

   a. Performance date of the given procedure.

   b. Condition of performance of procedure.

   c. Type of procedure and description.

   d. Parameters measured and their values, including values measured prior to calibration or correction, as applicable.

   e. Parameters associated with calibration or corrective networks, components, or devices.

   f. The names of personnel conducting the procedure.

   g. The equipment used to conduct the procedure

B. Audio System Tests

1. Before connecting loudspeaker lines to audio power amplifiers, measure and record the impedance curves of each line using a sweep test or an impedance meter with at least four test frequencies from 100 Hz through 10 kHz. Perform impedance testing with all loudspeakers connected to the line and all in-line volume controls set for maximum level (no attenuation). Where an external impedance matching transformer is used (external power amplifier), measure and record both the impedance as seen by the transformer and as seen by the amplifier. Correct any lines found to have improper impedance.

2. Test all microphone and line level audio wiring and connections from end to end for continuity, ground faults and correct polarity.

3. Apply a sine-wave sweep signal to each loudspeaker system from 50 Hz to 5 kHz at a sound pressure level that is 10 dB below the loudspeaker's rated electrical input power. Listen for rattles or objectionable noise and eliminate these at the source.

4. Subjectively check for loudspeaker polarity miswiring in distributed loudspeaker systems by applying pink noise to each system and listening while walking through coverage transition areas for any apparent shifting of source from one loudspeaker to the next. If potential polarity problems are perceived, physically check the connections and make any required wiring corrections.

5. Achieve uniform distribution of sound from each loudspeaker system after all interior furnishings are in place. Drive each system with one full octave of noise centered at 4 kHz at a level of 85 to 90 dB. Use a sound level meter that meets ANSI

ST 4-1971 Type 2 set for slow meter damping and "A" weighting. Take all readings at seated ear height. Adjust loudspeaker aiming (or transformer taps in the case of distributed ceiling systems) as necessary to achieve ±3 dB or less variation over the entire seating area. Provide a plan drawing of measured 4 kHz sound distribution from each system, plotted on a 10-foot square grid pattern. The process of optimizing sound systems often requires physically moving or adjusting certain component parts (e.g., loudspeaker horns). Provide this service, if required, without claim for additional payment.

6. Provide a list of all build-out, termination and pad resistor circuit calculations. Include measured line and source impedances used in calculations, results of tests after installation and impedance of all inputs to equipment brought up on patch bays. Impedances in ohms shall be within ±10% of design value. Levels in dB shall be within ±1dB of design value.

7. Perform gain stage adjustments and optimization as follows:

   a. Turn power amplifiers on, but all the way down.

   b. Send a 1 kHz a sine wave signal through the audio mixer at a level just below output clipping as observed on an oscilloscope.

   c. Increase the input and then the output gain of each device downstream in the signal path until the oscilloscope indicates the level in and out of each device is just below clipping. For each device under test, find the input clipping threshold (if the device has an input attenuator) before adjusting its output attenuator. If the input attenuator on any device lacks sufficient padding to prevent clipping, insert the minimum value pad required to achieve an input level just below clipping.

   d. When all line level gain stages have been optimized for maximum signal-to-noise ratio as described above, play pink noise through the audio mixer and adjust the power amplifier levels, one channel at a time, to achieve the desired sound pressure level in each listening area covered by a given channel.

C. CATV System Performance – Check all paths and outlets for appropriate compliance with the Performance Standards. Measure levels at all feeder termination points. Compare actual values to design calculations and investigate any difference of more than 2 dB, rectify or justify these discrepancies to the satisfaction of the Owner. Where not specified, FCC Rules Part 76.605 shall apply. In all cases, the more stringent of any referenced standard shall apply.

1. Television Distribution System amplitude standards:

   a. Minimum visual sync-tip level: +3 dBmV
   b. Maximum visual sync-tip level: +10 dBmV
   c. Maximum amplitude difference between visual carriers 6MHz apart: 2 dB
   d. Maximum amplitude difference between any visual carriers: 7 dB
   e. Minimum visual/aural carrier ratio: 15 dB

f. Maximum visual/aural carrier ratio: 17 dB
g. Maximum FM station amplitude: -7 dBmV
h. Minimum FM station amplitude: -20 dBmV
i. Maximum variation between FM stations on adjacent channels: 3 dB
j. Long-term variations in amplitude: 8 dB

2. Television Distribution System frequency standards:

   a. Visual frequency accuracy: +5 kHz of standard channel frequency
   b. Intercarrier frequency: 4.5 MHz, ±1 kHz
   c. FM frequency accuracy: +2 kHz of standard channel frequency.
   d. Television Distribution System flatness standards:
   e. Amplitude response within any TV channel: +0.5 dB (-0.75 MHz to +3.6 MHz from visual carrier)
   f. Amplitude response for entire spectrum (50 Hz - 750 MHz): 4 dB

3. Television Distribution System fault standards:

   a. Maximum hum or low-frequency variations: 2% p-p
   b. Minimum visual carrier-to-noise ratio (4 MHz BW): 47 dB
   c. Maximum visual carrier-to-coherent spurious signal ratio (intermodulation): -53 dB
   d. Maximum Cross modulation ratio: -53 dB
   e. Maximum reflections within system: -40 dB
   f. Television Distribution System isolation:
   g. Minimum drop-to-drop isolation: 25 dB

4. Television Distribution System signal leakage:

   a. 15uV/M maximum (at 100')
   b. Television Distribution System Video Standards:
   c. Chroma / Luma Delay: not more than 170 ns
   d. Differential Phase: not more than 8 degrees
   e. Differential Gain: not more than 10%
   f. Sweep and balance reverse system path

5. CATV Cable Testing – Inspect each Trunk Cable line shall for proper termination as follows:

   a. Using a standard TV receiver connected to each outlet, observe picture quality. No visible components of cross modulation (windshield wiper effect), ghosting, noise or beat interference shall appear on the screen of the receiver tuned to any normal signal.

   b. Perform carrier-to-noise tests using an approved field strength meter. Measure at the termination of each Trunk Cable and system extremity. With the normal levels in the system, tune the field strength meter to the picture carrier of each channel in turn and record the meter reading. Tune the field strength meter to an unused portion of the spectrum within the passband. Read the level of remaining

noise in the absence of the signal and algebraically add the meter bandwidth correction factor. Record the difference between the two readings. Provide calculations or the manufacturer's data concerning the bandwidth correction factor.

c. Perform system flatness tests, both forward and reverse, using an approved high level sweep transmitter receiver pair. Take sweep measurements at every branch line termination in the system. Record sweep results by computer data logging, if possible, or by means of photographs.

3.3 SYSTEMS STARTUP

A. Provide a statement of completion certifying that the system is installed, fully operational and ready for acceptance testing and adjusting by the Architect's Consultant.

B. Schedule a time for the Architect's Consultant to perform acceptance testing and adjusting with at least 14 days advance notice.

C. Schedule all instrumentation used for Field Quality Control tests along with the same technicians who performed these tests to assist the Architect's Consultant with final acceptance testing and adjusting. Include installation personnel who are authorized, capable and properly equipped to make any required changes in the installation including correction/completion of punch list items.

3.4 ADJUSTING

A. Assist the Architect's Consultant in system testing/adjusting including, if necessary, any re-aiming or reconfiguration of loudspeakers or re-tapping of line transformers required to achieve uniform sound distribution throughout listener areas as directed by the Architect's Consultant.

B. Record the results of acceptance testing/adjusting including, but not limited to:

1. Final control settings for all non-user operated equipment including electronic/software settings and the physical position of control knobs, sliders and switches.

2. Measured audio system frequency response curves, equalized and non-equalized, for each listener area along with corresponding 1/3 octave data tabulated on an Excel worksheet.

3. Input and output signal levels for all audio equipment measured in dBmV.

3.5 CLEANING

A. Remove all unnecessary tools and equipment, unused materials, packing materials and debris from each area where Work has been completed unless designated for storage.

B. Clean all areas around system equipment and be sure that the inside of each equipment rack is free of wire stripping and other debris.

3.6 CLOSEOUT ACTIVITIES

A. Demonstration – Upon completion of the Work, the Owner may elect to verify test data as part of the acceptance procedure. Provide personnel and equipment, at the convenience of the Owner, to reasonably to assist with such tests and demonstrate system performance without additional cost to the Owner.

B. Training – Provide a minimum of 24 hours on-site instruction of the Owner using technicians who are familiar with and qualified to operate the systems. Coordinate instruction times through the Architect. Cover the design features and proper operation of the systems. Provide video recordings of the training sessions. Make any Owner requested changes to the control system programming during this time.

END OF SECTION

SECTION 28.00.00
ELECTRONIC SAFETY AND SECURITY

1. GENERAL

This Entire Section, including all of the sub-sections herein, comprises the details for design, installation, commissioning and ongoing support of a complete, comprehensive, fully integrated Security Solution to include the following functionality:

- Access Control
- Intrusion Detection
- Video Surveillance

1.1. SUMMARY

A. This Section specifies the minimum requirements for the Key West City Hall at Glynn Archer, 1300 White Street, Key West, Florida 33040. This Electronic Safety and Security System shall include but is not limited to the following:
   AA) Electronic Access Control and Intrusion Detection
   BB) Electronic Surveillance

B. Work in this Section includes: Furnishing and installation of the specified software and hardware products with all required cabling/wiring (as noted), Project Management, supervision, coordination with; the end user/client, General Contractor, other trades, Architect and Security consultant, project data collection, software programming, system testing, system commissioning, end user training and documentation to provide a complete and properly functioning, fully integrated system. This Section corresponds to the "T" and "TS" series of drawings.

C. This Section was prepared by: John Weston, Defenbaugh & Associates, Inc. Please read the entire Section and associated drawings. Any technical questions should be directed to:

   John Weston
   john.weston@unified.us.com
   mobile: 214.384.3463

   You can call with questions but they must be followed up with written questions by email. Responses will be distributed as Addendum(s) to this Section. No verbal statements will constitute any change to this Section.

D. Related Requirements:

1. AA) and BB)

a. Must be from one of the stated manufacturers. No alternates will be reviewed.

b. Any part of the integrated solution must be able to function autonomously during a failure of one of the related sections

c. All parts of the integrated solution must be able to communicate bi-directionally (full duplex)

d. All parts or the integrated solution must be Interfaced through digital communication protocols including, but not limited to:

1) ASCII

2) Hexidecimal Data Transmissions

3) Other high level, full duplex, digital computer language

e. Bidder's response must be provided as a fully integrated, "turnkey" solution

1.2. ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate with owner regarding camera network configuration and estimated bandwidth utilization prior to connection of cameras to owner's network.
2. Coordinate with General Contractor, Architect, other trades and owner on all door hardware connectivity and end user utilization.
3. Coordinate with General Contractor, Architect, other trades and owner on connectivity and interface between the Access Control system solution and the building elevators.
4. Provide a list of participants to attend weekly construction coordination and progress update meetings until job completion. Indicate whether bidder plans to attend by conference call or in person at the job site, based on the master schedule.

1.3. SUBMITTALS

Submittals described in this section shall be submitted by the Contractor with the original bid.

A. Product Data

1. Submit manufacturer technical specifications, typical installation drawings, system overview drawings and sample images of items included in this section.

B. Meeting the Performance Specification

1. It is the duty of the contractor/bidder to provide a working system based on the performance specifications set forth herein. It is the complete responsibility of the bidder to remedy any omissions, errors or differences between this document and the contractor/bidder submitted proposal at NO CHARGE to the owner/end user.

C. Qualification Statements

1. Manufacturer

a. Submit confirmation and details of manufacturer's warranty, extended warranty, and replacement policies.

b. Submit proceeding 1 year financial statements for the equipment manufacturer.

c. If applicable, submit list of manufacturer provided, fee based professional services that are included in this bid proposal including but not limited to: training, installation, commissioning, remote diagnostics and integration with 3rd party software and hardware systems.

2. Integrator

a. Submit confirmation that integrator/contractor is licensed to install video surveillance and security equipment as required by the authority having jurisdiction.

b. Submit history of integrator/contractor certification(s) for items in this section.

c. Submit references with contact information where integrator/contractor has installed items in this section.

d. Submit confirmation that Integrator/contractor has received manufacturer training and is certified by the manufacturer on this equipment and that the training the installer received is current.

e. Submit proceeding 1 year financial statements for the Integrator/contractor.

f. The successful Bidder for this Section will be required to furnish a performance and payment bond of approved form through an approved bonding company duly authorized to do business in the State of Florida, and currently listed in the Department of Treasury Federal Register, in the amount not less than 100% of the contract price for the Solution quoted in this Section, conditioned upon the performance of the contract. Performance and Payment Bonds shall be in full compliance with Florida Government Code. Bonding Companies using "Reinsuring Insurance Companies" to expand the Bonding Companies limits will not be acceptable unless also approved by the City of Key West Florida.

g. Submit the Integrator/contractor's current Insurance Certificate

h. Maintenance material submittals

D. Spare Parts

1. Create a list for a recommended appropriate Hardware "Crash Kit" and provide pricing details so that the end user can determine if they want to purchase this as an option.
2. Spares shall be housed in an environment and condition recommended by the manufacturer and shall be clearly labeled with "SPARE: DO NOT REMOVE", manufacturer part number, and date of delivery to the owner.
3. All packaging for spares must be kept in good condition and used as appropriate for any Returns to Manufacturer (RMA).

1.4. QUALITY ASSURANCE

A. Qualifications

1. Manufacturer

   a. All Manufacturers shall have been in business for more than 5 years.

   b. All Manufacturers provide complete Level 2 Technical and Engineering Support for the complete, integrated solution.

2. Integrator

   a. All Access Control, Intrusion Detection and IP Video Surveillance hardware and camera installation, configuration, setup, programing and related work shall be performed by authorized integrators/electronic technicians certified by the manufacturers.

   b. Certification for authorized integrators/electronic technicians shall include at a minimum the installation and service of the equipment provided.

3. List of approved Integrators
FOR A COMPLETE, COMPREHENSIVE, FULLY INTEGRATED SECURITY SOLUTION.

A. Description of work

The Contractor is to use the above Security System, Request for Proposal, Section 28 00 00 to solicit bids from any or all of the manufacturer certified Security Integrators listed below. Any Security Integrator not shown on the list MUST PROVIDE proof of manufacturer certification for the Accepted Products listed in Section 28 00 00, in order to be considered for review of their proposal. Submitted Bids will be reviewed by Bender & Associates and their project team; including Defenbaugh & Associates for technical compliance.

B. Vendor List

Justin Peterson
President
Integrated Fire & Security Solutions
7857 Drew Circle Suite 15
Fort Myers FL 33967
Office 239-415-4374 ext 229
toll free (888)955-0007
Cell 239-425-7644
jupeterson@ifssi.com
www.fireandsecurityteam.com

Rich Montalvo

President
Security 101 Fort Lauderdale
1520 N. Powerline Road
Pompano Beach, FL 33069
USA
1-888-909-4101 Office
954-984-4282 FLL Office
954-812-2201 Cell
rmontalvo@security101.com
www.Security101.com
For Service: SFL-service@security101.com

Todd Galimidi
Integrated Security Systems
1876 N.W. 7th Street
Miami, Florida 33125
305.248.8800
1.888.670.2226
tgalimidi@teamiss.com
www.teamiss.com

Danielle Armenti
Senior Security Consultant
Rapid Security Solutions
3600 S Congress Ave, Ste G
Boynton Beach, FL 33426
Phone: (561) 641-9186 x 1007
Mobile: (561) 876-5566
darmenti@rsecurity.net
www.rsecurity.net

Jorge Fernandez
Siemens
Mobile 954.415.2654
Jorge.o.fernandez@siemens.com

Jim Fairbanks
SiteSecure, Inc.
Mobile 561.722.6004
jfairbanks@sitesecure.com

1.5. CERTIFICATIONS AND STANDARDS

A. Certifications

1. Submit copies of all appropriate State License and Manufacturer Certifications.

1.6. WARRANTY

A. The Integrator/contractor shall provide a single written document outlining the warranty of the manufacturer(s) product and the contractor's installation, on a single document. The document shall warrant complete installation of all services and equipment to be free from defects in materials and workmanship for a period of no less than 1 year starting with the date of Final System Acceptance.

B. The Integrator/Contractor shall provide any software maintenance patches and version updates or upgrades at no-additional cost to Owner for a period of at least 1 year and provide details if this service is provided for a longer period of time at no charge.

C. The Integrator/Contractor will provide a cost budget for up to a total of 5 years for the maintenance and upgrades to the system. The budget must clearly define all contractor and manufacturer costs expected.

1. Provide pricing for the following SLA's (Service Level Agreements)

   a. Remote Support 1 hour response to start corrective action and work through to completion.

   b. On Site Support 6 Hour response to be on site to start corrective action and work through to completion.

2. PRODUCTS

PLEASE NOTE; ALL EQUIPMENT PROPOSED MUST BE NEW.

AA) ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION

2.1. SCHEDULES

A. Statement

1. It is the duty of the Integrator/Contractor to provide a working system based on the performance specifications set forth herein. It is the complete responsibility of the bidder to remedy any omissions, errors or differences between this document and the contractor/bidder submitted proposal at NO CHARGE to the owner/end user.

B. Schedule includes equipment location information referenced in T and TS series drawings

1. KEY WEST CITY HALL Glynn Archer, 1300 White Street, Key West, FL

   a. Proposed Operations

   1) The new City Hall will include a dedicated Data Center with power conditioning and Uninterruptable Power Supply, backed up by an emergency generator on site.

   2) The requested Integrated Security Systems servers will be located in this Data Center.

   3) There will be diverse routing of Telco and Data Services into the building.

4) There will be dedicated private network connectivity to the Key West Police Department Building.

5) The City will use a local alarm monitoring company.

6) The City will provide all LAN (including POE services), MAN and WAN connectivity for this project.

b. Equipment Schedule for Security System Device Details

Location #	Door Type	Devices for Security System	Door Hardware (Provided by others)	Notes
100A	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		
East Elevator	NA	Card Reader at Call Button	NA	Integrate to Elevator
105	Interior Single	Card Reader	Storage Electric lockset	Add cylinder lock
		Door Contact		
		PIR		
110	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		
107	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
110A	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		
114	Interior Double	Card Reader	Electric Lockset	Add cylinder lock
		Door Contacts		+ Security grill
		PIR		

Location #	Door Type	Devices for Security System	Door Hardware (Provided by others)	Notes
115	Exterior Double	Card Reader	Electric Lockset	Add cylinder lock
		Door Contacts		
		PIR		
		Glass Break Sensor		
		Intrusion Alarm Keypad		East Building
115A	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
119	Exterior Double	Door Contacts	Standard	Manual Lock Inside only/no external hdwr
		Glass Break Sensor		
124A	External Single	Door Contact	Standard	Add cylinder lock
		Glass break Sensor		
124C	External Single	Door Contact	Standard	Add cylinder lock
		Glass break Sensor		
124B	External Single	Door Contact	Standard	Inside only/no external
		Glass Break Sensor		
124D	External Single	Door Contact	Standard	Inside only/no external
		Glass Break Sensor		
125	Single Internal	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
128	External Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
		Intrusion Alarm Keypad		Auditorium
129	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		

Location #	Door Type	Devices for Security System	Door Hardware (Provided by others)	Notes
130B	Exterior Double	Door Contacts	Electric Lockset	Inside only/no external
		PIR		
		Glass Break Sensor		
135	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
129A	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		
129B	Exterior Double	Door Contacts	Standard	Manual lock
		PIR		
		Glass Break Sensor		
135A	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
WestElevator	NA	Card Reader at Call Button	NA	Integrate to Elevator
147	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
148	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
152	Exterior Double	Door Contacts	Standard	Inside only/no external
		PIR		
		Glass Break		
142	Exterior Double	Card Reader	Electric Lockset	Add cylinder lock
		Door Contacts		
		PIR		
		Glass Break Sensor		
		Intrusion Alarm Key pad		West Building

Location #	Door Type	Devices for Security System	Door Hardware (Provided by others)	Notes
142A	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
205B	Exterior Single	Door Contact	Standard	Inside only/no external
		PIR		
		Glass Break Sensor		
226	Exterior Single	Door Contact	Standard	Inside only/no external
		PIR		
		Glass Break Sensor		
215	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		PIR		
		Door Contact		
259A	Exterior Single	Door Contact	Standard	Inside only/no external
		PIR		
		Glass Break		
244	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
242	Interior Single	Card Reader	Electric Lockset	Add cylinder lock
		Door Contact		
		PIR		
235	Exterior Single	Door Contact	Electric Lockset	Inside only/no external
		PIR		
		Glass Break Sensor		

2.2 ACCESS CONTROL SYSTEM WITH INTEGRATED INTRUSION DETECTION

C. Acceptable Manufacturers:

1. Genetec
    a. Product: SecurityCenter Synergis Access Control Solution
2. Software House
    a. Product: CCure 9000 Access Control Solution

3. Bosch
    a. Product: G Series Intrusion Detection Solution Panels and Network Interface
4. HID
    a. Products: iClass SE R40 MultiClass readers and (200) HID iClass SE MultiClass Access Cards
5. Servers
    a. Dell (or OEM branded Dell)
    b. HP (or OEM branded HP)
6. No other Manufacturers accepted.

D. Centralized Access Control and Management System

The Centralized Access Control and Management System (ACS) shall provide the capabilities to control all aspects of the SYSTEM, interface with all main control components at the facility, and provide the ability to centrally control access and egress, and to monitor and track events. Door events shall integrate with the Video Surveillance system described within this specification.

1. Architecture Requirements

The ACS shall meet the following architecture and usage requirements:

- Utilize a single database for all functions
- The database must have an interface, application or utility to automatically search, extract and update records via LDAP of the Owner provided directory services.
- Vendor shall provide an explanation and examples of how the system interfaces with directory services via LDAP. The example shall include a description of how users may be automatically enrolled into the system and how access rights can be modified through changes of status within Owner provided directory services.
- Expansions or upgrades for system scale shall not require the installation of a different or new application
- The ACS shall be able to interface and monitor system controllers, reader interface modules and input/output panels
- ACS tasks shall be available through the network to any appropriately equipped client workstation, and/or through a compatible Internet browser application

2. Capabilities and Functionality Requirements

The ACS shall meet the following capabilities and functionality requirements:

- The software shall support an unlimited number of card readers, input points, intrusion detection points, and relay outputs
- The database shall server(s) shall support an unlimited number of cardholders, transactions and SYSTEM events (as permitted by disk storage, database manufacturer record limits, and server memory)
- Concurrent connectivity from Client Workstations shall be limited only be the server operating system software and server hardware

- All alarms and events shall be recorded in the database and shall support the option to log or to not log events on any particular input or reader
- The ACS shall allow administrators to trace activity on any alarm, input, output, detection device or card reader
- Alarms and events shall be capable of being filtered or routed to one or more client workstations on the network
- The ACS shall be equipped with the capability of email or paging notification for configured alerts or events
- The ACS shall be equipped with remote monitoring and control through VPN, thin client or remote control (terminal services) over the Internet or WAN
- The ACS shall provide the ability to schedule or apply on-demand actions for the following:
    1. Arm/Disarm an area
    2. Open door or door group
    3. Facility lock down
    4. Activate/Deactivate input or outputs
    5. Enable/Disable predefined camera tours or modes
    6. Perform software or user record updates to field controllers

- The ACS shall support the use of graphical maps to display device status and use icons to indicate device locations. The security vendor shall produce electronic maps for the facilities and include all installed device locations within the system interface. The maps shall have the ability to be printed and support the following formats:
    1. Windows Bitmap (.bmp)
    2. TIFF (.tif)
    3. JPEG (.jpg)
    4. Windows Metafile (.wmf, .emf)

3. Communications Requirements

The ACS shall meet the following communications requirements:

- The ACS shall be able to communicate with the Field Main Control Panels (MCP) via the following protocols:
    1. RS-232
    2. RS-485
    3. TCP/IP
    4. Dial-up via Modem
- The primary (normal operating mode) of communication for the ACS to MCP shall be via TCP/IP
- Dial-up sessions shall have the ability to be scheduled or initiated on demand
- Communication via the ACS and the MCP shall be fully multi-tasking and shall not interfere with normal operating functions
- Each MCP within the facility shall provide a survivability mode in the event there is a loss of communications between the ACS and the MCP
- All activities during the loss of communications shall be logged at the MCP and shall be synchronized with the ACS once communications are re-established

4. Door Hardware and Power Supplies for Control Components and Hardware

The ACS shall be powered centrally by Altronix AL600ULXB power supplies (or

equivalent). These shall provide appropriate DC voltage where applicable. The power supplies shall be located within locking, wall-mounted enclosures in existing IDF/Server Rooms.

- *Please note that others within the master scope of this project will provide all of the door hardware.*
- Quantities as required to support all locks and control panels.

5. Fire Alarm System Interface
The Bidder will provide the interface point, Access Control system programming, testing and coordination with the Fire Alarm system provider. The interface point will include the relay module and necessary cabling.

6. Signage
The Bidder will provide any wall signage required by City of Key West code, specific to exit control hardware. The pre-production proofs of the signage must be approved by the Architect prior to order.

C. Control and Equipment Configuration
The Access Control (ACS) component of the SYSTEM shall provide monitoring of each controlled door, and shall consist of the following types of components:

- (DC) Door Contact Sensor
- (PIR) Motion Sensor
- (AKP) Alarm Keypad
- (PB) Panic Button
- (GB) Glass Break Sensor

See the full list on sheet TS1.00
The ACS shall integrate with the exiting installed/provided door hardware.

1. Capabilities and Functionality Requirements
ACS shall meet the following requirements:

- The ACS shall be capable of defining a minimum of 24 Time Zones each with a minimum of four intervals
- Time Zones shall be applied to access levels, card reader modes, alarm inputs and outputs
- Times Zones shall be allowed to belong to any or all access levels
- Access Levels shall consist of a combination of card readers and time zones
- The ACS shall be capable of 32 access levels per cardholder
- Card readers shall have the ability to be assigned to any or all Access Levels
- The ACS shall support Access Groups which contain definable Access Levels
- The ACS shall provide a minimum of 24 Holidays assignments utilizing an embedded calendar
- Access rights must be able to be altered when the data is set to a Holiday
- The ACS shall support a cardholder usage limit to specify the maximum number of times a cardholder may use their credentials at any given card reader

- The ACS shall support Extended Door Times per the R40 Key pad that allow individual end users unique parameters for the following:
    1. Extended strike times
    2. Extended door held open
- The ACS shall support Wiegand card formats
- Access cards shall provide the ability to be deactivated on a pre-determined period of time or event
- The ACS shall be able to monitor door status (open/closed) and determine forced door events
- All doors and ACS components shall be powered by a centralized power supplies

D. Licensing

The ACS shall include licensing for at least (10) concurrent users and (10) installed seats at client workstations. Installation at client workstations shall be completed by Bidder/security integrator.
Software platform must allow for the addition of 10 more concurrent users without requiring a migration to a new platform or product level or product offering.

BB) ELECTRONIC SURVEILLANCE

2.1 SCHEDULES

A. Statement

1. It is the duty of the contractor/bidder to provide a working system based on the performance specifications set forth herein. It is the complete responsibility of the bidder to remedy any omissions, errors or differences between this document and the contractor/bidder submitted proposal at NO CHARGE to the owner/end user.

2. THE VIDEO SURVEILLANCE FUNCTIONALITY EXPECTED IS AS FOLLOWS:

- Video Surveillance will run 24 x 7.
- Video images from the primary server will be stored for one month and then be overwritten.
- All cameras shown are fixed, megapixel models, with the exception of the two (2) PTZ model cameras on the plan west side of the building to cover the parking areas. Outdoor rated cameras will have to include a heater and/or blower. It is preferred that the outdoor rated camera have a built in or integrated heater and/or blower. An acceptable alternate would be to include an external enclosure with built in heater and/or blower for designated outdoor cameras. All cameras will have remote focus, automatic iris and exposure adjustment.
    - The primary, dedicated, Administrative workstation with full access rights to all cameras will be located in the IT department at the new facility. This workstation will be the only position with access rights to copy and/or download stored image files off the system.
    - In addition The City of Key West plans to provide a dedicated network link to:

The City of Key West Public Safety Department Building

- So that when requested the PS Department will have private network web access to the entire Integrated Access Control, Intrusion Detection and Video Surveillance system for real time live feeds.

B. Schedule includes equipment location information referenced in T and TS series drawings

1. KEY WEST CITY HALL Glynn Archer, 1300 White Street, Key West, FL

a. Proposed Operations

1) The new City Hall will include a dedicated Data Center with power conditioning and Uninterruptable Power Supply, backed up by an emergency generator on site.

2) The requested Integrated Security Systems servers will be located in this Data Center.

3) There will be diverse routing of Telco and Data Services into the building.

4) There will be dedicated private network connectivity to the Key West Police Department Building.

5) The City will use a local alarm monitoring company.

6) The City will provide all LAN (including POE services), MAN and WAN connectivity for this project.

b. Equipment Schedule for Video Surveillance Device Details

C. VIDEO SURVEILLANCE CAMERAS

The minimum cameras specified: Avigilon, Axis, Bosch or Sony shall have the following minimum features and capabilities:

- *Please carefully review the notes in the table of cameras below, as to:*
  - *observed lighting conditions*
  - *day/night requirements for IR illumination*
  - *area of view/depth of field.*
- Cameras shall support day/night functionality
- Where requested Cameras shall support Wide Dynamic Range (WDR)
- Cameras shall support a minimum of 3 megapixel and 16:9 ratio HD 1080p video format, with the understanding that where specifically requested; WDR functionality would be 16:9 ratio HD 720p video format
- Camera should provide image file that can be digitally manipulated for pan, tilt and zoom for distances specified in the table above.
- Cameras shall support remote focus and auto Iris control
- Cameras shall per capable of recording up to 30 frames per second (FPS) for all resolutions
- The City of Key West will review cameras proposed based on best of class pixels on target specifications
- Cameras shall be Power over Ethernet (PoE) Class 3 compliant.
- Internal Cameras shall have an integrated housing in mini-dome format
- External Cameras shall have heater/blower function either integrated or by use of external housing, with a preference for fully integrated function using (PoE) Class 3 LAN power.

- The (2) requested PTZ cameras will be provisioned with local 110v power supplies.
- Shall support H.264, JPEG2000 Progressive Lossless Compression, Motion JPEG or MPEG-4 video streams, with a preference for H.264 video stream
- All cameras/housings shall include appropriate mounting brackets/hardware for affixing cameras to walls/ceilings
- Cameras shall be capable of receiving external triggers from third party devices as well as triggers from motion detection to initiate alarms and image transmission
- Shall provide light sensitivity to 1 lux
- Cameras shall support TCP/IP over Ethernet of at least 100baseTX (Fast Ethernet)
- Please describe any additional standard features of your camera solution, such as Auto-discover and Auto-configure.
- *PLEASE NOTE that The City of Key West will provide the dedicated POE LAN switch to power and connect all of the cameras and required LAN ports for this system.*

ACCEPTABLE CAMERA MANUFACTURERS & MODEL REQUIREMENTS

Brand	**(A) Indoor**	**(B) Indoor WDR/Advanced**	**(C) Outdoor Day/Night**	**(D) Outdoor PTZ Day/Night**
Avigilon	3.0W-H3-DC1/2	3.0W-H3-DC1/2	3.0W-H3-DP1/2	NA
Axis	P3367-V	P3384-V	P3367-VE	Q6045E
Bosch	NIN-932	NIN-733	NDN-932	NA
Sony	EM631	EM601	EM632R	NA

NO OTHER MANUFACTURERS ARE ACCEPTED.

Camera ID	Camera Type	Furthest distance to view in feet	Building location
Building Complex Floor 1			
CAM-01-1	C	20	At Door 119 facing NE
CAM-02-1	C	20	At Door 100 facing SE
CAM-03-1	C	20	At Door 100 facing NE
CAM-04-1	C	20	At Door 110 facing SE
CAM-05-1	C	20	At Door 130B facing SW
CAM-06-1	C	30	At Door 129A facing NW
CAM-07-1	C	30	At Door 129B facing SW
CAM-08-1	C	20	At Door 152 facing NW
CAM-09-1	C	30	At Door 115 facing NW
CAM-10-1	B	20	Inside Lobby 100 facing East
CAM-11-1	C	30	At Door 110A facing SW
CAM-12-1	B	20	Inside Cor 110, facing S to Doors 107 & 110
CAM-13-1	C	15	At Door 128 facing SW

CAM-14-1	C	30	At Door 129 facing SE
CAM-15-1	C	30	At Door 142 facing NE
CAM-16-1	B	30	Inside Cor 129 facing N
CAM-17-1	B	30	Inside Cor 129 facing S
CAM-18-1	A	10	Inside Room 148
CAM-19-1	A	15	Inside Room 153, facing Customer window
CAM-20-1	B	15	Inside Area 129T facing the Cash Register
Building Complex Floor 2			
CAM-01-2	C	30	At Door 205B facing West
CAM-02-2	C	30	At Door 226 facing West
CAM-03-2	C	30	At Door 259A facing East
CAM-04-2	C	30	At Door 235 facing East
CAM-05-2	A	20	Inside East Stair 215 facing West
CAM-06-2	A	20	Inside West stair 242 facing east
CAM-07-2	D	80	Outside, NW Corner, facing West
CAM-08-2	D	40	Outside, SW Corner, facing West

2.2 NETWORK VIDEO MANAGEMENT SERVER(S)

E. Acceptable Manufacturer(s):

1. Avigilon server Hardware and Storage Expansions
2. Genetec server Hardware and Storage Expansions
3. Other Manufacturers accepted
    a. Dell (or OEM branded Dell)
    b. HP (or OEM branded HP)
    c. No other manufacturers accepted

F. The Video Management System shall allow the use of off-the-shelf computers, servers, storage and switches from any manufacturer with components that meet the minimum requirements.

1. Contractor shall supply all 19” rack support rails, mounting kits, and cable management modules to install Video Management servers.
2. The Performance requirements for the VMS server are as follows:
    - 2x Dual Core Intel® Xeon® 5150, 2.66 GHz, 4 MB Cache, 1333 MHz FSB
    - 4 GB of RAM
    - 80 GB of storage or more
    - Additional hard drive(s) for video storage
    - Standard WUXGA video card
    - 1920 x 1200 or higher screen resolution
    - 10/100/1000 Ethernet Network Interface Card

- DVD ROM Drive
- REDUNDANT POWER SUPPLIES

    a. Hard Drive: SATA-II 7200 RPM Enterprise Class. Bidder shall determine Video Archiving solution and determine hard drive capacity.

3. Internal Storage Hard Drive(s): SATA-II 7200 RPM in RAID5 configuration

   Bidder will calculate total storage requirements based on the following criteria:

   - Dedicated server configuration to support the total number of cameras in the project with N+1 hot standby failover if any one server fails.
   - NVR shall be configured to store images from all cameras calculated with 50% motion
   - The standard recording speed will be calculated at 10 frames per second (FPS) per camera and support up to 10% of the total cameras running at 30 FPS.
   - Recorded or live video shall be available to view from any workstation on the network
   - The NVR (primary server and/or servers) shall be capable of processing all of the raw image feeds from all of the cameras for this solution. Configure primary server with enough multiple 1 GB NIC ports to support proper throughput from the Core LAN switch.
   - The Archive Server Array (secondary servers) shall be capable of storing and archiving 30 days worth of recorded video and provide high-resolution playback from the megapixel cameras using a high capacity drive array. Configure secondary server with enough multiple 1 GB NIC ports to support proper throughput form the core LAN.

     a. Operating System shall be certified to work by the Video Management Software's manufacturer and be one of the following: Windows server 2003 SP2, Windows server 2008, or Windows 7. A 64-bit operating system.

2.2. NETWORK VIDEO MANAGEMENT WORKSTATION

STATEMENT: One (1) Workstation with two (2) 30" to 32" video monitors HD1080p shall be configured for this project. Other end users defined as part of the solution design will use PC browser function to access all systems software.

A. Acceptable Manufacturer:

1. Manufacturers accepted

   a. Dell

   b. HP

   c. No other manufacturers accepted

B. The Video Management Workstation shall allow the use of off-the-shelf computer components that meet the minimum performance requirements.

   The Performance requirements for the VMS workstation are as follows:

   - Intel® Core®2 Quad 2.40 GHz or higher, 4 MB Cache, 1066 MHz FSB

- 4 GB of RAM
- 250 GB of storage or more
- Standard WUXGA video card
- With Dual video output ports, DVI or HDMI
- 1920 x 1200 or higher screen resolution
- 10/100/1000 Ethernet Network Interface Card
- 16x DVD+/- RW Drive1

2.4 NETWORK VIDEO MANAGEMENT SOFTWARE

A. ACCEPTABLE MANUFACTURERS and PRODUCTS

1. Avigilon
    a. Product: Control Center 5.X
2. Genetec
    a. Product: SecurityCenter Omnicast (most current software release)
3. No other Manufacturers accepted.

B. Contractor shall provide all applicable Network Video Management Software (NVMS) modules and licenses required to provide a complete and fully functional integration.

C. The NVMS shall be installed on hardware which meet or exceed the manufacturer's recommended requirements:

D. The design and performance requirements for the NVMS software are as follows:

1. The NVMS shall be available as a stand-alone software offering or pre-loaded on turn-key workstations and servers running Microsoft Windows with configurable storage.
2. The NVMS shall be available in a staged licensed software solution at three levels:
    a. Enterprise
    b. Standard
    c. Core.
3. The NVMS shall be an enterprise level software solution that shall be scalable from one client, server and camera up to:
    a. 20 servers per Site.
    b. 64 cameras per server or 1,280 cameras per Site
    c. Indefinite number of concurrent client to Site connections, limited only by the bandwidth capability of the network and server.
4. The NVMS shall consist of server software applications and client software applications.
5. The NVMS shall include a gateway software application that connects mobile devices and other thin clients to the NVMS.

a. The NVMS mobile client shall be supported by:

1) Android mobile devices
2) Apple mobile devices.

b. The NVMS thin web client shall be supported by:

1) Internet Explorer, Chrome, and Firefox web browsers on Windows desktops.
2) Safari, Chrome, and Firefox web browsers on Macintosh desktops.

6. The NVMS shall be available in the following languages:

a. English
b. Spanish

7. The NVMS shall include but not limited to the following applications:

a. server Software Applications

1) Core Software Server
2) System Admin Tool
3) Software Gateway Function

b. client Software Applications

1) End User Client
2) End User Web client
3) End User Player
4) Camera Installation Tool
5) Mobile client
6) Gateway Web Client (HTML5)

8. The NVMS shall permit server and client software applications to be installed and run on both the same computer or on separate computers.
9. The NVMS shall support storage and processing of video and audio.

a. Audio and video must be recorded natively from the camera with no transcoding.
b. Audio and video must be synchronized regardless of frame-rate, resolution or bitrate.

10. The NVMS shall support dynamic video stream management architecture which includes:

a. Support for industry standard compression formats including but not limited to:

1) H.264
2) JPEG2000
3) MJPEG

4) MPEG-4

b. The client and server machine shall communicate resolution real estate such that the server machine acts as a video proxy and shall know the maximum monitor resolution supported by the client machine.

c. Support for reducing the required client bandwidth and processing power of a megapixel video stream by transmitting only the fraction of the video stream that is visible in the video display tile. (e.g. If a user is viewing a 5MP camera in a 352x240 resolution tile then a CIF representation of the 5MP image shall be transmitted).

d. Support for reducing the required client bandwidth and processing power of a multi-megapixel video stream by transmitting only the relevant portion(s) of the whole scene when the client is zoomed-in to view only a portion of the scene.

e. Support for "data-aging", enabling a low quality and high quality stream to be recorded under the same logical ID. After an administrator defined period of time, the higher stream would be deleted and the lower stream would remain until the end of the desired retention period.

1) The NVMS shall provide the ability to reduce the image rate of recorded JPEG and JPEG2000 video over time as a means of increasing record time. The image rate can be reduced to one half or one quarter of the original image rate. This setting can be configured separately for each JPEG and JPEG2000 video source.

2) The NVMS shall provide the ability to record and maintain a primary and secondary video stream for a set amount of time before the primary stream is discarded as a means of increasing record time. This setting can be configured separately for each H.264 video source.

f. Dynamic video stream management shall be supported for local users, remote users and mobile devices.

11. The Network Video Management Software (NVMS) shall support recording and management of video and audio sources through the use of industry standard drivers. These drivers shall include:

a. ONVIF Profile S

b. Publically Published API

12. The Network Video Management Software (NVMS) shall support recording and management of video and audio sources including but not limited to:

a. Avigilon IP H.264/JPEG2000 Cameras and encoders

b. Axis Cameras/Encoders

c. Bosch

d. ONVIF 1.00, 1.01, and 1.02 Cameras

e. Sony Cameras

13. The NVMS shall support receiving digital input triggers and triggering digital outputs through an I/O board.
14. The NVMS will provide the mechanism by which individual alarm(s) from a 3rd party system (access control, etc.) can be pre-selected and configured to be monitored, and in turn trigger event driven video operations.
15. The NVMS shall support recording and monitoring video and audio streams from sources with bandwidth up to 90 Mbit/sec, frame rate up to 60 fps, and video resolution up to 29 MP (6576 x 4384).
16. The NVMS shall support the decompression of H.264 video through the client graphics card/graphical processing unit instead of using the client processing power.
17. The NVMS shall require no proprietary recording hardware, no hardware multiplexer or time-division technology for video and audio recording or monitoring.
18. The NVMS shall not limit the storage capacity and shall allow for upgrades of recording capacity without additional licensing.
19. The NVMS shall secure video and audio data by securely transmitting all command and control data via TCP/IP using cryptographic keys based on SSL to prevent eavesdropping or tampering.
20. The NVMS shall support software level integration via an Application Programming Interface (API). The API integration shall include but not limited to:
    a. Bi-directional alarm event processing for monitoring and acknowledgement
    b. Receiving card access activity events
    c. Receiving digital input events
    d. Receiving intrusion zone events
21. The NVMS shall support integration with the following systems:
    a. Genetec SecurityCenter Synergis
    b. Software House CCure 9000
22. The NVMS client shall provide alarm management operations specific to access control through the use of the client graphical user interface. Including but not limited to:
    a. Occurrences for “Alarm” and “Reset” conditions for each of the pre-selected access system alarms will be processed and managed from the NVMS system’s Live View workspace.
    1) In a section reserved for displaying alarm notifications or from an alarm viewer.
    2) Alarms can also be acknowledged from the camera display tile.
    b. Once an initiated alarm occurrence is acknowledged from the NVMS system, it should be automatically acknowledged and processed in the access system alarm monitor queue without further operator intervention.
23. The NVMS shall have an easy process for upgrading versions:

a. Are capable of being upgraded from one version to another without having to uninstall the previous version.

b. Are capable of being upgraded from one edition to another without having to uninstall the application.

c. Automatically detect if video or audio source firmware is out of date with respect to the current installed software and upgrade it.

d. Automatically detect if client application software is out of date with respect to the current installed server software and upgrade it.

24. The NVMS shall run as a service configured to automatically start when the server or workstation is powered on, and automatically recover from failure or attempted tampering.

25. The NVMS shall allow users to monitor and administer the system from:

    a. A single client application for monitoring live and recorded video and audio.

    b. A single window for administrating all system connections.

    c. Any client located on the network.

26. The NVMS shall provide an automatic discovery solution that will easily find devices and systems by:

    a. Automatically discovering server instances that run on computers connected to the same network as the client.

    b. A search functionality to discover server instances running on computers connected on a different network segment than the client by using IP addresses or hostnames.

    c. Automatically discovering video and audio sources that are connected to the same network as the server.

    d. A search functionality to discover video and audio sources that are connected on a different network segment than the server.

27. The NVMS shall provide multiple methods for providing fault tolerant solutions to maintain high availability recording in mission critical installations including:

    a. The ability to cluster and synchronize up to 20 servers into a Site without a management server. In the event of a server failure, the system is able to continue running and other servers can take over the failed server's tasks.

    b. The ability to maintain a centralized system administration so that the same operation and system configuration settings are shared between all servers in a Site. This allows the same user login details and other configurations to be used across a Site, and ensure that the settings remain active even if a server fails.

    c. The ability to connect a video or audio source to multiple NVRs to achieve redundant recording.

d. The ability to create a failover connection for a video or audio source. If the NVR that the video or audio source is connected to goes offline then the failover NVR will take over the connection.

28. The NVMS shall support receiving Simple Network Management Protocol (SNMP) messages from servers and alert users.
29. The NVMS shall detect if the video or audio signal is lost and alert the system administrator.
30. The NVMS shall provide the capability to rename all video and audio sources and NVRs.
31. The NVMS shall record video and audio streams based on a recording schedule that can be defined individually for each video source. The schedule shall include but not limited to the following parameters:
    a. Recording Mode
    b. Continuous
    c. Motion
    d. Digital Inputs
    e. Alarms
    f. POS Transactions
    g. License Plates
    h. Time and Date Settings
    i. Daily
    j. Weekly
32. The NVMS shall provide the ability to manually trigger recording.
33. The NVMS shall provide a pre-event and post-event recording option.
34. The NVMS shall provide a reference frame recording option in the absence of events.
35. The NVMS shall perform motion detection on each individual video source with adjustable sensitivity, threshold and detection zones.
36. The NVMS shall provide the ability to set a maximum recorded video retention time for each video source.
37. The NVMS shall perform dynamic bandwidth management to ensure the total bandwidth does not overload the system.
38. The NVMS shall authenticate users before granting access to the system. Access rights for each user can be defined individually for each user, and shall include but not limited to:
    a. Viewing live images
    1) Using PTZ controls
    2) Locking PTZ controls
    3) Trigger manual recording

4) Trigger digital outputs
5) Listen to microphones
6) Broadcast to speakers

b. Viewing recorded images

1) Exporting images
2) Backup recorded images

c. Manage user sessions
d. Connect and disconnect cameras
e. Setup cameras

1) Setup general settings
2) Setup network settings
3) Setup image and display settings
4) Setup compression and image rate
5) Setup image dimension settings
6) Setup motion detection settings
7) Setup privacy zone settings
8) Setup manual recording settings
9) Setup digital input & output settings
10) Setup microphone settings
11) setup speaker settings

f. Setup servers

1) Setup general settings
2) Setup schedule settings
3) Setup recording and bandwidth settings
4) Setup user and group settings
5) Setup alarm management settings
6) Setup scheduled backup settings
7) Setup POS transaction settings
8) Setup email settings
9) Setup rule engine settings
10) View system log

g. Access to individual video and audio sources

39. The NVMS shall provide the ability to rank access rights based on a user's position within a hierarchy.

    a. Ranked users may only administer changes to users and groups that are subordinate in rank.

40. The NVMS shall support multiple credentials to gain access to the system including, but not limited to:

    a. The ability to import members of Active Directory groups as users in the NVMS.

    1) Changes made to members in the Active Directory are automatically synced with the NVMS.

    b. Using Windows credentials to authenticate users.

    c. Accept user credentials entered into the NVMS user database.

41. The NVMS shall provide the ability to schedule backups of recorded video with associated events to a local folder or mapped network drive.

42. The NVMS shall provide the ability to create and schedule alarms and corresponding actions including:

    a. Provide the ability to email users and system administrators when an event or system health error occurs.

    b. Provide the ability to schedule when email notifications are sent.

    c. Provide the ability to include camera images in email notifications.

43. The NVMS shall maintain an event log. Including but not limited to the following events:

    a. Server events

    1) Server application starting up
    2) Server application shutting down
    3) Server application terminated unexpectedly
    4) Server application low on resources
    5) Server application installation error
    6) Licensed feature expires soon
    7) Licensed feature expired
    8) Database error
    9) Data initialization error
    10) Data volume failed
    11) Data volume recovered
    12) Data volume size reduced
    13) Data write error
    14) Data upgrade started

15) Data upgrade completed
16) Data upgrade failed
17) Data recovery started
18) Data recovery completed
19) Data recovery failed
20) Network connection found
21) Network connection lost
22) Network error
23) Network error resolved
24) Email send error
25) server hardware error
26) Backup started
27) Backup completed
28) Backup failed

b. Device Events

1) Connection created
2) Connection removed
3) Connection created to standby server
4) Connection removed from standby server
5) Connection failure
6) Connection restored
7) Network packet loss unacceptable
8) Network packet loss acceptable
9) Motion detection started
10) Motion detection ended
11) Recording started
12) Recording ended
13) Recording interrupted
14) Recording resumed
15) Digital input activated
16) Digital input deactivated
17) Firmware upgrade started
18) Firmware upgrade completed

19) Firmware upgrade failed

c. User Events

1) User login
2) User logout
3) server setting changed
4) Device setting changed
5) Device connected
6) Device disconnected
7) Digital output triggered
8) Bookmark added
9) Bookmark updated
10) Bookmark deleted
11) PTZ moved
12) PTZ idle
13) Export performed
14) Speaker activated
15) Speaker deactivated

d. Alarm Events

1) Alarm acknowledged
2) Alarm auto acknowledged
3) Alarm triggered
4) Alarm assigned
5) Alarm unassigned
6) Alarm purged

e. POS Transaction Events

1) POS transaction started
2) POS transaction ended
3) POS transaction exception

f. License Plate Recognition Events

1) License plate detection started
2) License plate detection ended
3) License plate watch-list match

44. The NVMS shall have the capability to schedule and execute any of the following actions in response to any of the events listed above:

    a. User Notification Actions

    1) Display on-screen message
    2) Send an email
    3) Play a sound

    b. Monitoring Actions

    1) Start live streaming video

    c. Device Actions

    1) Reboot camera
    2) Trigger digital output

    d. PTZ Actions

    1) Go to Preset
    2) Run a Pattern
    3) Set Auxiliary
    4) Clear Auxiliary

    e. Alarm actions

    1) Trigger an alarm
    2) Acknowledge an alarm

45. The NVMS shall provide the ability to escalate alarms from one user or group to another if the alarm is unacknowledged for a preset duration.
46. The NVMS shall provide the ability to create customized on-screen messages and email notifications.
47. The NVMS shall provide a maintenance log and audit trail of all system errors and events.
48. The NVMS shall support the operation of a Point of Sale system that include:

    a. The ability to receive transaction information from point-of-sale sources.
    b. Support multiple encoding formats from point-of-sale sources.
    c. The ability to monitor live and recorded transactions from point-of-sale sources with linked video.
    d. The ability to generate events based on point-of-sale transaction exceptions.

49. The NVMS shall support the operation of a License Plate Recognition system that include:

    a. The ability to define a region of an image where license plate detection is performed. Detected license plates shall be stored with the video data.

b. The ability to create a Watch List that is used to create events when specific license plates are detected in the images being analyzed.

50. The NVMS shall provide the ability to enable and configure PTZ control on the RS-485 interface of a video source.

51. The NVMS shall support PTZ protocols. Including but are not limited to the following:

    a. Axis

52. The NVMS shall provide the ability to change the network settings for a video and audio source including:

    a. A change in image quality and image rate parameters for a single video source shall not affect the settings of other video sources.

    b. The ability to enable a secondary stream for live viewing.

    c. The ability to change the exposure, iris, IR filter, backlight compensation, gain, priority, sharpening, saturation, focus, and white balance settings for a video source.

    d. The ability to change the image dimensions for a video source.

    e. The ability to rotate the image 90°, 180° or 270° for a video source.

    f. The ability to add privacy zones to a video source to block unwanted areas in the image field of view.

    g. The ability to set a maximum recording duration for manually triggered recording for a video source.

    h. The ability to change the input, output, gain and volume for an audio source.

53. The NVMS shall support the use of uni-directional and bi-directional audio.

    a. The NVMS shall support full-duplex two-way audio communication.

    b. The NVMS shall provide the ability to link any audio source to any video source.

    1) Able to link multiple audio sources to a single video source.

    2) Able to link an audio source to many video sources.

    c. The NVMS shall provide the ability to synchronize audio and video on playback regardless of video, audio, network, or storage parameters

54. The NVMS shall provide the ability to set a maximum for bandwidth transmitted to the Control Center Client application from the Control Center Server application.

55. The NVMS shall provide the ability to manage operator access to the NVMS and assets, including:

    a. Ability to automatically log in to an NVR.

    b. Ability to override user access to an NVR if there are insufficient licenses.

c. Ability to automatically log out of an NVR when the application is left idle.

d. Ability to save and restore the window layout.

56. Ability to control the system using a PC keyboard or joystick.

57. Ability to import and export system settings such as maps, views, web pages, users and groups.

58. The NVMS shall support live or recorded video monitoring of 1 to 64 video streams simultaneously on a single monitor with the following standard layouts:

    a. Full Screen

    b. 2 x 2

    c. 3 x 3

    d. 4 x 4

    e. 5 x 5

    f. 6 x 6

    g. 8 x 8

    h. 1 + 5

    i. 1 + 7

    j. 1+ 12

    k. 2 + 8

59. The NVMS shall support live or recorded video monitoring in a customizable video display beyond the standard layouts.

60. The NVMS shall offer a Matrix Application Module to provide remote control of multiple monitor displays, including video walls, that can be controlled by an unlimited number of users with appropriate rights and permissions.

61. The NVMS shall support the ability to bias the displayed video to a lower frame rate or to a lower image resolution if the client network bandwidth or processing power is insufficient for displaying the video at full frame rate and image resolution.

62. The NVMS shall support the ability to display image overlays. Including but not limited to the following:

    a. Camera Name

    b. Camera Location

    c. Timestamp

    d. Record Indicator

    e. Motion Activity

    f. License Plate

63. The NVMS client software shall:

a. Not limit the number of monitors used for monitoring video and audio streams connected to a single workstation.

b. Support monitoring live and recorded video and audio streams simultaneously on the same monitor.

c. Support viewing the same live or recorded video stream at different zoom levels and areas of interest.

d. Support the ability to switch from live to recorded video on demand for an instant replay of recently recorded video.

e. Support the ability to share the application window display in a joint session with other users for collaborative investigations.

f. Support the creation of unlimited views with unique layouts of video streams.

g. Support the ability to toggle between tiled and full-screen view.

h. Support the ability to save views.

i. Support the ability to cycle through views (guard tour) based on a specified interval.

j. Display all video sources connected to the system.

k. Support the ability to drag and drop sources from a system tree. Sources include but are not limited to:

1) A video/audio source for live and recorded display.

2) A predefined layout view of video/audio sources.

3) Third party or integrated devices

4) Web pages

5) Graphical maps

64. The NVMS shall support the ability to configure how the system tree is displayed.

a. The system tree of video sources, maps, saved views and web pages can be organized into virtual folders that are represented as branches within the Site.

b. Users can be granted access to individual items or entire folders within the tree.

c. New items added to a folder automatically inherit the permissions of that folder.

65. Alarm and Event Management:

a. The NVMS shall support monitoring alarms.

b. The NVMS shall support the ability to designate one or more regions/tiles in a window for displaying video directly linked to triggered alarms and rules.

c. The NVMS shall support the ability to acknowledge alarms from the designated video display area.

d. The NVMS shall support the ability to manually trigger digital output:

1) Through the use of a pre-configured software “button”.

2) Through the use of a hard-wired dry alarm contact connected to a supported input/output device.

e. The NVMS shall support the ability to assign alarms to users.

f. The NVMS shall support the ability to acknowledge alarms.

g. The NVMS shall support the ability to bookmark alarms.

66. The NVMS shall support creating bookmarks for recorded video and audio. Bookmarks can be:

a. Viewed from multiple sources,

b. Displayed on the timeline during playback,

c. Used as a search criteria for recorded video and audio. Search criteria can include but are not limited to:

1) Bookmark name

2) Notes

3) Linked camera names

d. The NVMS shall support protecting a bookmark so the video and audio data is never overwritten.

e. The NVMS shall support private bookmarks that are only visible to the user who designated a bookmark as private, and the system administrator.

67. The NVMS shall support the ability to create a map that represents the physical location of cameras and other devices throughout the surveillance system.

a. Maps shall be created from images stored in standard image formats. Including but not limited to the following:

1) JPEG

2) BMP

3) PNG

4) GIF

b. Maps shall have the ability to contain links so as to create a hierarchy of interlinked maps.

c. Maps shall support the ability to drag and drop a video source from the map into a window for live or recorded video and audio monitoring.

d. Maps shall support the creation of a link to a preset section of a video source.

e. Cameras in a map are highlighted when an alarm linked to the camera is triggered.

f. Maps shall support the ability to include a link to a web page and view the web page in the application window.

68. The NVMS shall support physical and digital zooming and panning on live and recorded video streams.

a. The NVMS shall support controlling mechanical pan-tilt-zoom, iris, and focus as well as setting presets and patterns.

b. The NVMS shall provide the ability to name pan-tilt-zoom presets.

c. The NVMS shall support the ability to center a PTZ camera's field of view by clicking anywhere on the video image where the PTZ supports this function.

d. The NVMS shall support the ability to click and drag to define an area for the PTZ camera to optically zoom and center on, where the PTZ supports this function.

e. The NVMS shall support controlling mechanical pan-tilt-zoom camera on-screen display and auxiliary controls.

f. The NVMS shall support locking PTZ controls.

g. The NVMS shall support control of a mechanical pan-tilt-zoom camera with a USB joystick.]

69. The NVMS shall support the ability to create PTZ guard tours by combining a set number of presets that are run in sequence or random.

70. The NVMS shall support playback of recorded video and audio.

a. Forward and reverse playback of recorded video and audio at variable speeds.

b. Audio and Video shall synchronously playback when:

1) Audio and video sources are linked

2) Audio and video sources populate different tiles within a synchronized playback layout.

71. The NVMS shall support the navigation of recorded video and audio. Including but not limited to the following methods:

a. Calendar

b. Timeline

1) The NVMS shall support a timeline that displays all connected video sources and the corresponding motion and recording events.

2) The NVMS shall support a timeline that can display the entire time range down to one second of recorded video and audio.

c. Events.

72. The NVMS shall support searching through recorded video and audio based on various search criteria. Including but not limited to the following parameters:
    a. Time
    b. Date
    c. Video source
    d. Alarm(s) and/or Event(s).
    e. Motion in user defined areas (pixel search).
    f. Point of Sales transactions
    g. License Plate detection events.
73. The NVMS shall support performing a search through a series of thumbnail images.
    a. Thumbnails can be based on the entire image region or a pre-selected area.
    b. Thumbnails can be stacked to support an automatic secondary search when looking at large timespan of video.
74. The NVMS shall support the ability to take a snapshot of a live or recorded image and export it from the system.
75. The NVMS shall support the ability to export recorded video in the following formats including but not limited to:
    a. Native
    b. JPEG
    c. PNG
    d. TIFF
    e. AVI
    f. WAV
    g. PDF
    h. Print
76. The NVMS shall support the ability to export recorded audio in WAV format.
77. The NVMS shall support the ability to export a live stream of images in the following formats:
    a. JPEG
    b. PNG
    c. TIFF
78. The NVMS shall support the ability to export video in Native format. Native format exported video shall:
    a. Digitally sign recorded video and audio using 256-bit encryption so video can be authenticated for evidentiary purposes.

b. Be able to export video from one or multiple camera streams simultaneously.

c. Support reviewing of exported video and audio in a secure client.

d. Support reviewing of backed-up video and audio in a secure client.

e. Support exporting of video in lower frame-rates than originally recorded.

f. Support exporting of a designated area of video from the camera's field of view.

g. Include camera properties. Including but not limited to:

1) Time zone
2) Recorded video and audio parameters
3) Event/alarm metadata
4) Vector motion and transactional data
5) Authentication keys to validate source authenticity/validity.

h. Support additional exporting into Native or open formats.

3. EXECUTION

3.1. PROPOSED OPERATIONS FOR EXTERIOR DOORS

During Normal Business hours:
These primary public doors are open:

West Building	West side	129A	
		129B	
	South side	129	
East Building	East side	109	
	South side	110	
	West side	110A	
Auditorium	North side	124C	*only when room is scheduled for public meetings
	South side	124A	*only when room is scheduled for public meetings

At all times.
The employee only, access controlled doors are: *these doors are access controlled from the exterior at all times and include an Alarm keypad inside each door.

West Building	East side	142
East Building	West side	115
Auditorium	South side	128

Exit only doors are: *these doors are monitored at all times for forced entry from the exterior, door held open too long and proper exit from inside

West Building	North side	152
		235
	South side	130B
		259A
East Building	North side	119
		205B
	South side	226

Auditorium	North side	124D	
	South side	124B	

After Normal Business hours
These primary public doors are manually locked:

West Building	West side	129A	
		129B	
	South side	129	
East Building	East side	109	
	South side	110	
	West side	110A	
Auditorium	North side	124C	*except when room is scheduled for public meetings, then manually locked at end of meeting
	South side	124A	*except when room is scheduled for public meetings, then manually locked at end of meeting

At all times.
The employee only, access controlled doors are:
*these doors are access controlled from the exterior at all times

West Building	East side	142	*gives approved access to stair well, which is also access controlled at floors 1 and 2
East Building	West side	115	*gives approved access to stair well, which is also access controlled at floors 1 and 2
Auditorium	South side	128	

Proposed Operations for Interior Doors and Elevators
During Normal Business hours
Elevators in the West and East Buildings are available for use

The following doors are access controlled at all times:

West Building	135
	135A
	148
	214
East Building	107

After Normal Business hours
Elevators in the West and East Buildings are access controlled at each first floor call button panel.

The following doors become access controlled:

West Building	142A
	242
East Building	114

115A
215

The following doors would be manually locked:
Auditorium 124
Other Department doors as required.

Once the entire the entire facility has been properly locked down at the end of the day, the last person out can arm the intrusion alarm system at one of the keypads located inside exterior doors 142 (West Building), 115 (East Building) or 128 (Auditorium).

The first person in to open the building, can disarm the entire system from any of the 3 Alarm keypads.

3.2. PROPOSED OPERATIONS FOR VIDEO SURVEILLANCE

The Video Surveillance functionality expected is as follows:

- Video Surveillance will run 24 x 7.
- Video images from the primary server will be stored for one month and then be overwritten.
- All cameras shown are fixed, megapixel models, with the exception of the two (2) PTZ model cameras on the plan west side of the building to cover the parking areas. Outdoor rated cameras will have to include a heater and/or blower. It is preferred that the outdoor rated camera have a built in or integrated heater and/or blower. An acceptable alternate would be to include an external enclosure with built in heater and/or blower for designated outdoor cameras. All cameras will have remote focus, automatic iris and exposure adjustment.

The primary, dedicated, Administrative workstation with full access rights to all cameras will be located in the IT department at the new facility. This workstation will be the only position with access rights to copy and/or download stored image files off the system.
In addition The City of Key West plans to provide a dedicated network link to:
The City of Key West Public Safety Department Building
So that when requested the PS Department will have private network web access to the entire Integrated Access Control, Intrusion Detection and Video Surveillance system for real time live feeds.

3.3. PHYSICAL ENVIRONMENT

The SYSTEM (Main Control Equipment) will be physically located inside one of the Data Cabinets in The City of Key West Data Center. It is required that all SYSTEM computer server equipment be rack mounted in standard 19” equipment cabinets. The Owner will provide the UPS for any servers.

Common Work Results for Electronic Safety and Security
Conductors and Cables for Electronic Safety and Security
All branch pathways and cabling from the devices (RS485 bus, door contact, network, etc.) shall be provided by Security vendors *with the exception of the category 6 cable to IP cameras.* (The

Structured Cabling Vendor will be routing all Cat 6 Cable to IP Cameras. All other security cabling should be included in the pricing for this proposal). Labor and materials for terminating, affixing, and dressing of all devices shall be provided by the security vendor and shall be included as an "Installation and Labor Cost" item in the pricing section of this document.
The vendor will be responsible for any cabling on access controlled doors for interconnecting the door control panels with door devices provided this cabling is limited to the controlled door location (home run topology to centralized controllers will be provided by other vendors). Power supplies, devices and connections for networked cameras, camera housings, controllers/panels cabinets and housings shall be provided by the security vendor. Additionally, any cabling required to locally interconnect SYSTEM panels (I/O, relay or network patch cables) shall be provided by the vendor. Pricing for these items shall be designated on a separate line item within the pricing section.

The vendor shall include installation and design for configuration of user groups, door configurations, camera tours, and user database population/integration from Owner data sources.

Pathways for Electronic Safety and Security

All pathways shall be coordinated with the chosen cabling vendor. All electrical boxes and local power outlets shall be provided by other vendors. Termination labor and materials of any of the SYSTEM components within the provided boxes shall be the responsibility of the SYSTEM vendor and shall be designated within the pricing section of this document.
Back boxes indicated on Security Plans shall be verified for compatibility with the proposer's solution, and shall be coordinated with the General Contractor prior to installation.

3.4 CABLING

All CAT6 cabling and Patch cables at the Data Center and IDF closets will be provided by the chosen low voltage cabling contractor. The CAT6 cable runs for each IP video camera will have been terminated with a male RJ45 jack and a 3 foot service loop. The City of Key West will coordinate all exterior camera locations and connections with the selected bidder.

3.4. PREPARATION

A. Prior to installation, the Network Video Management System shall be configured and tested in accordance with the manufacturer's instructions.

B. INSTALLATION

1. Install system in accordance with manufacturer's instructions.
2. Perform all work in accordance with acknowledged industry and professional standards.

C. SYSTEM SOFTWARE

1. Develop, install, and test software and databases for the complete and proper operation of systems involved. Assign software license to Owner.

2. The Contractor is responsible for the entire programming and setup of the system such that no additional programming is required. Programming shall include the setup of all available features of the software.
3. Perform a full system back-up at completion of initial programming and deliver the configuration to the Owner.
4. Perform field software changes after the initial programming session to "fine tune" operating parameters and sequence of operations based on any revisions to the Owner's operating requirements.

3.5. DOCUMENTATION, TRAINING AND SUPPORT

A. System Documentation

The vendor shall document each component of the SYSTEM
During installation, the vendor shall maintain a separate hard copy set of drawings, elementary diagrams, and wiring diagrams of the SYSTEM to be used for record drawings. This set shall be kept up to date with all changes and additions to all components of the SYSTEM.
The final as-built documentation shall be provided to the owner within 30-days of final SYSTEM cutover. Copies shall be provided in a hard copy drawing set, and on CD

B. Submittal Documentation

Prior to installation of any component, the vendor must submit to the Owner a Submittal Package consisting of the following information:
Shop Drawings – Indicate all system device locations on architectural floor plans (AutoCAD).
Full schematic wiring information for all devices
Product Data – Data sheets specifying manufacturer's technical data for all material and equipment.
An initial binder organized by sections as outlined in this document shall be included prior to initial project start.
The vendor shall document each component of the SYSTEM
The vendor must allow two weeks for the Owner's review and comments
Any deviations to the approved Submittal Package must be accompanied by written Owner approval

C. Contractor System Cutover Support

The Contractor shall provide on-site support for the entire cut over period.
At a minimum, the Contractor must provide the Project Foreman beginning when the cut over commences. The Project Foreman must remain on-site until dismissed by the Owner. The Contractor's Project Manager must be on-call for the duration of the cut over to assist the Project Foreman in the event assistance is required.
The Contractor's on-site personnel must be equipped with toners, testers, and other miscellaneous equipment

D. General Training Requirements

The following section defines the training requirements associated with the implementation of the proposed system. These training requirements are an integral part of the system proposal. All pricing associated with training is to be included in the response.
All SYSTEM user training must be performed at the Owner's site.

The successful bidder will be required to equip a customer-provided training room with the enough working equipment to facilitate group training. The bidder must describe this equipment configuration.
The bidder is required to provide sufficient training personnel to train 10 users over a period of 1 day.
User training must cover all basic and enhanced features associated with each type of instrument installed as part of this RFP.
The bidder agrees to perform all training in a time frame set by the Owner and as close to the cutover date as possible.
The bidder agrees to provide at least 2 copies of original manufacturer-supplied training materials and user guides for all equipment covered in this RFP. One full printed copy and one electronic copy
The bidder agrees to provide training to 2 customer trainers to assist the customer ongoing training of personnel ("train the trainer").

E. System Administration Training
The bidder must provide complete system administration training on all proposed systems for two administrators.
Define the administration training course, what topics are covered, the length of time of the training and where the training is to be held.
Describe any Manufacturer provided training or certification programs available to Owner personnel. Provide details on classroom training locations available, self-paced training, or online training modules.

3.6 PRICING DETAILS for review after award of contract.

A. Cabling Quantities

The Security vendor shall provide all of the following types of cable for this project:
The Security Vendor shall provide all other quantities required to install the Access Control System and devices as specified. This quantity shall be equal to the footages identified in the selected vendor's shop drawings. Deviations and costs from these quantities and the actual pulled quantities by cabling contractor shall be the responsibility of the security vendor.
This cabling will be purchased and installed as described above**.** The quantities shall include footages required for appropriate service loops and dressing in all technology rooms and pathways to camera locations.

Complete the following table for all cable types:

ITEM	Quantity Required (ft.)
Cable Type (each required)	

B. Pricing Response

The bidder agrees to furnish and install the System as specified and defined in this specification. Prices must include all materials, labor, engineering, coordination, programming, training, supervision, project management, testing and any other tasks required to deliver a working security

system in accordance with this document..

1. Cost Itemization

1.1 Complete the following table for the project:

ACCESS CONTROL/INTRUSION DETECTION ITEM	Quantity Supplied	Unit Hardware Cost	Extended Cost	Category Total
Access Control/Intrusion Detection				
HID iClass SE R40 Key Pads				
(200) HID iClass MultiClass SE Cards				
Door Contact Sensors, PIR and Glass break detectors				
Alarm panel/key pads				
Door Controller Panels				
Input/Output Panels				
Main Control Panels				
Fire System Interface				
Central Power Supply				
Miscellaneous Hardware				
Software License cost				
Dedicated Server				
Installation and/or labor cost				
TOTAL				

VIDEO SURVEILLANCE ITEM	Quantity Supplied	Unit Hardware Cost	Extended Cost	Category Total
Fixed Cameras				
NVR Servers				
Miscellaneous Hardware				
Dedicated Workstations				
Software License Cost				
Installation and/or labor cost				
Labor to decommission and remove existing analog cameras once the new system has been commissioned				
TOTAL				
Performance Bond				
PROJECT TOTAL				
Optional Crash Kit				

Pre-purchased Maintenance pricing for software assurance (no charge upgrades and updates) and for system component must be included for years listed. Alternate comprehensive maintenance coverage may be provided as a separate line item

System Maintenance *PROVIDE A (6) HOUR ON SITE SLA, WITH (1) HOUR SLA FOR REMOTE RESPONSE*	Annual Fee for full on site service	OPTION FOR Annual Fee for Software/Tech support only
Year 1		
Year 2		
Year 3		
Year 4		
Year 5		

2. Labor Budget

Please provide your detailed labor budget showing hours for the following elements:

Labor Task	Project hours required	Hourly rate
Project Management		
Design/programming/ installation of hardware and software		
Installation of cameras		
Cabling installation		

3. Labor Rates

For future work please identify labor rates for the following. If there are labor rate differentials based on technicians' skill sets, identify each.

Type	Rate
Business Day	
Overtime	
Weekend/Holiday	
Trip Charge	
Additional Training (per day and hour)	

END OF SECTION 28 00 00

SECTION 283111

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Addressable interface device.
9. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

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. 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. Licensed.

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.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

C. Sample warranty.

1.4 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.
    d. Riser diagram.
    e. Record copy of site-specific software.
    f. 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.

    g. Manufacturer's required maintenance related to system warranty requirements.
    h. 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.

1.5 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).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.6 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: 2 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 Siemens (used as Basis of Design), Simplex, Notifier

2.2 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 addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

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

2.3 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire-extinguishing system operation.
7. Fire standpipe system.
8. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode. Interface with BMS system.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Activate preaction system.
8. Recall elevators to primary or alternate recall floors.
9. Activate elevator power shunt trip.
10. Activate emergency lighting control.
11. Record events in the system memory.
12. Interface with Auditorium Sound System for audio shutdown.

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. Elevator shunt-trip supervision.

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, or remote annunciator.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. After a time delay of 180 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.4 PERFORMANCE REQUIREMENTS

2.5 FIRE-ALARM CONTROL UNIT

A. Siemens(used as Basis of Design), Simplex & Notifier.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
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. Capable of being disabled for control functions.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.

E. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

F. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.

3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

    a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

G. 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.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. 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 and digital alarm communicator transmitters 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.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.6 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38.

    1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
    2. Station Reset: Key- or wrench-operated switch.

2.7 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

    1. Comply with UL 268; operating at 24-V dc, nominal.
    2. Detectors shall be two-wire type.
    3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
    4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. 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. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. 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.

2.8 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature or a rate of rise.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, [**red**] [**white**].

2.10 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match

those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.11 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:
1. Operate smoke dampers.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Secondary Power: Integral rechargeable battery and automatic charger.

E. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 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."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

C. Equipment Mounting: Install fire-alarm control unit on finished floor.

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

F. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install 80” to center of xenon lamp or as required by local jurisdiction. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 PATHWAYS

A. Pathways shall be installed in EMT.

B. Fire Alarm Junction Boxes shall be painted red enamel.

3.3 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. Smoke dampers in air ducts of designated HVAC duct systems.
2. Electronically locked doors and access gates.
3. Alarm-initiating connection to elevator recall system and components.
4. Alarm-initiating connection to activate emergency lighting control.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
7. Supervisory connections at elevator shunt-trip breaker.
8. Supervisory connections at fire-extinguisher locations.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 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.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction and City Construction Manager.

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

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 NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter.
    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.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. 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.

3.7 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.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111